INTERACTIVE HOMEWORK: CONTEXTUALIZING BLACK GIRLS' MATH IDENTITIES IN A FAMILY-SCHOOL PARTNERSHIP

by
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Abstract

This research addressed family-school partnerships and parents' self-efficacy with supporting their daughters' math learning—2 factors identified in a needs assessment as being likely to contribute to the problem of math underperformance of Black girls. The needs assessment was situated at a public Montessori charter school in a Mid-Atlantic city; the pre/postembedded exploratory design intervention occurred in a traditional school in the same city. In this embedded exploratory research design, biweekly, interactive homework was given to a treatment group of approximately 40 fourth-grade students. No comparison group was available. The interactive homework contextualized math learning within key areas of students' lives, including family and school. This research explored how contextualizing learning within these key relationships would support parents' self-efficacy with supporting their daughters as math learners, increases in math scores, and increases in students' sense of themselves as math learners.

Keywords: Black girls, math underperformance, family-school engagement, public Montessori, parent self-efficacy, TIPS interactive homework

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Dedication

I dedicate this work to my mother, Guenivere Robbins. Thank you for modelling how to respect and explore diverse perspectives without becoming someone other than who yourself. And thank you for a lifetime of good food, rich texture, garden tours, and abundant opportunities. I love you so much!

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Table of Contents

List of Tables

List of Figures

Executive Summary

Robert Moses, former Student Nonviolent Coordinating Committee member and the founder of the Algebra Project, wrote that math illiteracy disproportionately pushes Black and minority students to become "the designated serfs of the information age (Moses & Cobb, 2001, p. 11). Moses observed that without math literacy, full economic access is not available, and Moses considered math literacy a key civil rights issue of this time (Moses & Cobb, 2001). Math literacy is no less a civil rights issue today, with 10% of the U.S. population claiming an increasing share of wage income (Garcia & Weiss, 2017). In the Mid-Atlantic city where this research intervention was conducted, low math literacy had persisted, often with Black students likely to be affected by pervasive opportunity gaps perpetrated by limited access to high-quality education. Researchers have suggested this lack of high-quality education derives from racially biased neighborhood districting policies, resource allocations, and funding formulas at the state and district level that underfund schools with the most need (Pietila, 2012; Rothstein, 2015; Roza, Hill, Sclafani, & Speakman, 2004; Tyack & Lowe, 1986). In 2017, 87% of Black eighth-grade students in Urban School District (a pseudonym), compared to 57% of White, 80% of Hispanic, 81% of Native American, and 38% of Asian students, scored below the proficient level on the Partnership for Assessment of Readiness for College of Careers (PARCC) math assessment (Annie E. Casey Foundation, 2017). Though these particular scores are not outstanding for any subgroup, the gap between the two largest school populations (White and Black) is concerning.

This achievement gap had been recognized as a problem in the urban school district where this research occurred; at the district level, educators have continued to seek solutions for the problem through professional development trainings and through continued experimentation with research-based strategies. These strategies have included restorative practices, holistic approaches, after school or summer programs, and culturally relevant curricula (personal communications, Public Charter Montessori [PCM] head of school to staff 2018-2019 school year; Urban District CEO to employees, 2018-2019 school year). Achievement gaps at some schools have narrowed, including at the school where the research intervention occurred, and individual Black students have continued to excel academically and to become leaders in science, technology, engineering, and math (STEM) careers. However, overall, a race-based disparity persists (Hansen, Levesque, Quintero, & Valant, 2018; Garcia & Weiss, 2017), and it continues to undermine the access that Black children in this urban city have to economic viability as adults. Dismantling the broader structures and institutional policies that perpetuate economic and social inequality might end this injustice to U.S. children. However, without the political will to make the kind of long-term commitments that might dismantle these structures—for example, a commitment to universal, high-quality early childhood education and healthcare, or to a living minimum-wage—educators continue an iterative process of implementing interventions to address such problems in professional practices, rather than the foundations of the problem.

The Math Underperformance of Black Girls

The problem observed and addressed by this research was the math underperformance of Black girls. Consistently low math scores is one indicator of underperformance, but underperformance can be any math achievement where students do not perform as well as expected based on their cognitive ability. Math underperformance may limit students' access to higher level classes that are the gateway to advanced STEM education or careers. Low self-efficacy about succeeding in these contexts may cause underperforming learners to decide to leave STEM fields, or their math achievement scores may be too low to gain access to advanced math learning opportunities. The researcher observed the underperformance of Black students at Public Montessori Charter School (a pseudonym) where she was a fourth- through sixth-grade teacher. This researcher observed consistently low scores by Black children who had often worked hard, demonstrated problem solving strategies, and were interested in learning (anecdotal). Though this anecdotal evidence indicated both boys and girls had underperformed, the researcher chose to focus on girls because the data for her class—while not generalizable to the rest of the school—showed a greater degree of underperformance of Black girls compared to other demographic groups.

Fourth-graders were chosen to participate in the intervention. Citywide PARCC (2014-18) data showed a decline in scores from third-to fourth grade. And although the overall mean scores did rebound somewhat in the fifth-grade, these scores had never fully recovered. By addressing math underperformance in the fourth-grade, the researcher intended to increase the likelihood that the participants would transition successfully to middle-school where academic achievement was a powerful predictor of outcomes in high school and college (see MacIver & Messel, 2012; Watts, Duncan, Siegler, & Davis-Kean, 2014).

Needs Assessment

To get a better sense of the factors underlying this problem, the student-researcher conducted a needs assessment at PCM. However, the intervention was conducted at another school, City Public School (CPS). Factors examined during the needs assessment included pedagogical strategies, teacher bias, social identities in relation to math learning, transmission of cultural capital from parent to child, and collaboration between parent and teacher. The needs assessment included exploring the literature to learn how Montessori pedagogy aligned with empirically tested pedagogical practices for educating Black children. Students took a Draw-A-Mathematician (DAM; Chambers, 1983) and completed a Math Attitude Test to learn more about their math identities related to math learning. To learn more about the connection between teacher bias and how teachers allocate resources, teachers took the Implicit Attitude Test (IAT), which was triangulated with observational data of how teachers interacted with their students. Though the sample size was too low to make the data reliable or valid, especially given that of the five participating teachers, only one reported the IAT data, the teachers' bias toward White boys in allocating attention in class was troubling. A focus group was also conducted with the parents of several Black girls in the class. Through the focus group, the researcher gathered information about the families' perspectives on different topics related to math learning.

The needs assessment findings (see Jeter, 2016) and subsequent informal interviews with parents of fourth-grade PCM students indicated parents desired stronger family-school connections focused on building student math literacy. Other constructs identified through the needs' assessment and determined as actionable included family-school collaboration and parent self-efficacy with supporting their daughters as math learners. Math achievement and math identity were other actionable constructs.

Research Context

Drawing on family feedback and research literature, the researcher chose an intervention that prioritized family-school partnerships. Substantial literature has shown parent engagement often aligns with stronger academic outcomes for Black girls (Archer, Dewitt, & Osborne, 2015; Berry, 2008; Eccles, 2005; Entwistle & Alexander, 1989; Epstein, 1988; R. Gutiérrez, 2000, O'Sullivan, Chen, & Fish, 2014; Van Voorhis, 2011). Parents of high achieving Black students often teach students to advocate for themselves in racialized educational institutions (McGee & Spencer, 2015). The chosen research intervention contextualized Black girls' math identities in a family-school interactive homework intervention: Teachers Involve Parents in School (TIPS) (Epstein & Van Voorhis, 2001). TIPS relies on Epstein's (1987, 2011) model of six types of family-school engagement, which positions the child within the dynamic and bidirectional interaction between family and school. Positioning academic content between the overlapping spheres of home and school is likely to increase the congruity between home and school environments, thereby enabling children to feel supported as math learners (Grantham & Ford, 1998). For the intervention, TIPS was used to contextualize math learning in a family-school partnership. Research has shown that students benefit through TIPS homework with increased homework completion (Epstein & Voorhis, 2001), more satisfaction with doing homework (Epstein & Dauber, 1991), and small, but significant academic gains (Voorhis, 2011). Another benefit of TIPS is that parents can participate and give feedback without having to be physically present in the school; thus, barriers to collaboration (e.g., include parents' work schedules, socioeconomic differences between family members and teacher, and teacher job satisfaction) are less likely to limit parent or family member participation (Leitch & Tangri, 1988).

Research Objectives

The overarching objective of this intervention was to explore how a home-based intervention that contextualized the math learning of Black girls in a family-school partnership would strengthen (a) parent self-efficacy, (b) student math achievement, and (c) student math identity. The theory of change was that participating in TIPS would increase student math achievement and parent or family members' self-efficacy with supporting their daughters as math learners. Subsequently, the math identity of participants was expected to increase.

Research Questions

RQ1: In what ways does participation in a home-based math intervention influence parental self-efficacy to support their Black girl's math learning?

RQ2: In what ways does participation in a home-based math intervention influence students' math identity?

RQ3: Over the course of the intervention, how do Black female students' descriptions of themselves as math learners converge with their academic scores?

Implementation

Research Design

Conducting research with a larger, more diverse grouping of schools would have increased the reliability, validity, and generalizability of the study, and it would have made it possible to have a comparison group against which to test the null hypothesis. Given the available resources, the research design chosen was a pre/postmixed methods research study with no comparison group. In this intervention, qualitative data describing the intervention process were embedded in quantitative strands of data. The researcher used the mixed methods design to explore participants' experiences with the interactive homework experience and to gather data to support future interventions (see Creswell, 2014).

Participants

Three schools agreed to participate in the intervention, but only CPS participated, and its 40 fourth-grade students determined the sample size. Of the 40 students, four did not sign consent forms, and another two moved during the school year. The focus group size (four Black girl-parent dyads) was determined based on a desire to keep the focus group large enough to collect a variety of responses and small enough that everyone would have a chance to talk. Ms. Vader (a pseudonym chosen by the teacher), the classroom teacher, also participated by collaborating with the researcher to choose homework, and by distributing and collecting, with high fidelity as measured by her adherence to biweekly protocol check lists, student homework.

Process

After gaining permission from CPS to conduct research, the researcher met with Ms. Vader to introduce the project rationale, protocols, and implementation and data collection processes. Vs. Vader collected consent forms for students and gave preintervention tests, including the DAM (e.g., Chambers, 1983) for children and Bandura's (1989) Multiple Scales of Personal Self-Efficacy test for adults. She also observed students and recorded her impressionistic sense of their confidence a work ethic with learning math. Ms. Vader then distributed TIPS homework to the students every 2 weeks following the research protocols. She collected each batch of homework, 12 in all, and returned each with a completed protocol sheet to the researcher.

Ms. Vader helped the researcher selectively sample participants for a focus group from the class. The researcher conducted the focus group to learn about the four participants' and their parents' experiences with the homework. After the 12 TIPS homework assignments had been collected, Ms. Vader collected the following postintervention data: DAM, Multidimensional Scale of Perceived Self-efficacy (MSPSE), the observational data, and student grades; these were used as a within-school assessment of math achievement. Students took an exit survey about their experiences with TIPS, and then students used the Family TIPS Survey to interview their parents. The researcher cleaned these data, analyzed the data, and drew conclusions based on those data.

Data Analysis

Quantitative and qualitative data were collected and analyzed separately. Results were then merged. Triangulation of quantitative and qualitative data provided cross-verification of the data (see O'Donnell, 2008). Quantitative data were analyzed descriptively and included student grades, homework completion percentages, DAM teacher observations of student confidence and effort with math learning, and MSPSE results. Qualitative included focus group transcripts, parents' feedback on TIPS homework, open-ended questions on exit surveys, and DAM responses. The thematic exploration of the qualitative data included three overarching themes:

- Family-school partnerships focused on math can help support mathematical self-efficacy for parents and their children.
- TIPS an interactive family-school homework provides a structure for parents to engage in a variety of activities that can support their daughter's math identity development and possible future school and workforce STEM aspirations.
- A strong math identity may help deepen learners' enculturation into the community of mathematical knowledge, practice, and belief.

Codes and subcodes that supported these themes were chosen deductively and inductively.

Research Findings

Research Question 1. When quantitative and qualitative data were integrated, the researcher noticed a connection between parents' support for their children and the self-efficacy development. Parents' participation in TIPS influenced some to change the ways that they would support their children as math learners.

Research Question 2. The increased student inclusion of math identity indicators, based on guidelines modified from Solomon's (2009) definition of math identity, supported the possibility that participation in a home-based math intervention would influence students' math identity development.

Research Question 3. Guided by Solomon's (2012) definition of math identity, girls in the focus group had developed the skills and behaviors needed to enculturate them in math communities of practice. There was a relationship between their math identities and their academic achievements, as measured by grades.

Discussion

Though findings were only impressionistic, the data showed a convergence among parent participation, parent self-efficacy, overall homework, work ethic, math identity, student self-efficacy, and student grades. This relationship existed across populations. Because the intervention itself contributed to any growth, it was inconclusive, as the gains experienced by students could be contributed to other factors.

Chapter 1

The Problem of Practice

The math underperformance of Black girls is a national trend. National Assessment of Educational Progress (NAEP, 2015) data showed Black girls at a double risk of math underperformance, by both ethnicity and gender. This researcher addressed the underperformance of fourth-grade Black girls. Though evidence has shown that early elementary math gains can predict math success in later elementary years, there is no evidence that this success is sustainable through middle-school where math skills become more complex (Duncan et al., 2007). Helping students in the fourth-grade to be academically successful might provide a bridge between elementary and middle school performance, which would have a strong benefit for students; ninth-grade math achievement—to a lesser degree eighth-grade math achievement—is a reliable predictor of high school outcomes (MacIver & Messel, 2012), and high school math achievement is a strong predictor of college degree achievement, future salary, and job quality (Watts et al., 2014). Fourth-grade students were chosen as the focus of this intervention both because of their comparatively weak math performance compared to other students at the needs assessment school and with the idea that increasing Black girls' connections to math might have a strong future influence. However, this researcher did not address how increased fourth-grade math achievement might align with stronger eighth and ninth-grade math scores.

The problem of practice, math underperformance of Black girls, was addressed as it existed in two elementary schools located in the same city. The first was PCM where a needs assessment was conducted. The second was CPS where the research intervention itself was conducted. In accordance with American Psychological Association guidelines (available on the website at https://www.apa.org/ethics/code/) to avoid bias and pejorative language; parents, step-parents, grandparents, older siblings, and other individuals who had played a caregiving role in the lives of the children studied were all referred to as *parents*.

Problem of Practice Within the Professional Context

In this paper, consistently low scores on standardized tests were considered a marker of underperformance. State-wide data collected by the Annie E. Casey Foundation (2017) showed underperformance. In 2017, 87% of Black eighth-grade students, compared to 57% of White, 80% of Hispanic, 81% of Native American, and 38% of Asian students in the Mid-Atlantic city had consistently scored below the proficient level on the PARCC math assessment (Annie E. Casey Foundation, 2017). Underperformance was evident at the needs' assessment site as well.

By fourth-grade, most Black fourth-grade students at PCM were not on track for college. The 2014-15 Northwestern Educators Assessment (NWEA, 2016) scores showed that only 25% of the Black girls and 33% of the Black boys, in the fourth-grade class studied, performed at a proficient or advanced (college track) level compared to 100% of the White male and female students. The school would no longer administer the NWEA; thus, longitudinal data for that test were unavailable. Aggregated data on the 2017 PARCC test for elementary students at PCM showed a 25% pass rate for White students compared to an 11% pass rate for Black students at PCM. Data were disaggregated to show how subgroups performed based on race and gender; however, no data showed performances at the intersection of race and gender. PCM's Black and White student populations were similar in size, allowing for a comparison between these subgroups. Students at CPS were 68% White, 24% Black, 4% Hispanic, 3% Asian, and 1% identify as more than one race. The school district aggregated data separately by race and gender. Based on a review of the urban district data, the median fourth-grade math PARCC score at CPS from 2015 to 2018 was 743, a relatively strong score. Fourth-grade girls had a median score of 734 compared to the fourth-grade boys with 739. By race, White students had a median score of

728; Black students' median score was 749. No median score was given for Asian or Hispanic students.

Rationale for Problem of Practice

Robert Moses, former Student Nonviolent Coordinating Committee member and the founder of the Algebra Project, wrote that math illiteracy disproportionately pushed Black and minority students to become "the designated serfs of the information age (Moses & Cobb, 2001, p. 11). He saw math literacy as a civil rights issue that affords individuals with advanced math skills more lucrative career choices than those with weak math skills. Indeed, 24- to 35-year old individuals with bachelor's or higher degrees in STEM fields continue to have higher median earnings compared to graduates from non-STEM fields with the exception of those with legal careers (U.S. Department of Commerce, 2015). Though the U.S. Department of Commerce (2015) employment data showed no gap between the percentage of Black and White employees who work in the computer or math field—5% of each group—a gender gap did exist, with 11% of men aged 24 to 35 working in mathematics and computers compared to 3% of women (U.S. Department of Commerce, 2015). The context of this research intervention was CPS, a public elementary school in a mid-sized, Mid-Atlantic city; however, the problem of math underperformance of Black girls was first observed in the student researcher's professional teaching context, a public Montessori school in the same city, PCM. The low math scores of Black girls at PCM on the NWEA is one marker of math underperformance, defined here as student achievement below expectation in relation to a student's math ability (see Steele & Aronson, 1995). Student scores on the PARCC test from 2016 through 2018 for students at both schools are another data point that indicates math underperformance. Math underperformance in elementary school limits student ability to take higher level math classes in middle and high school, and subsequently makes entering high paying math and tech jobs less feasible. Thus, finding strategies that support math learning for girls while they are still in elementary school is likely to increase their future academic and employment opportunities.

Theoretical Frameworks

Critical race theory (CRT) and Bourdieu's (1986) idea of cultural reproduction were the primary frameworks used to investigate the problem of practice. According to cultural reproduction theory, economic capital can be converted into cultural capital, which can be leveraged to support academic achievement. Bourdieu (2001) explored socioeconomic status as a form of social capital; toward the end of his life, he addressed the power of gender when "the social order functions as an immense symbolic machine tending to ratify the masculine domination on which it is founded" (p. 9). He wrote little about race, but several critical race theorists had defined race as a form of capital, and when customs, laws, and standards of normalcy reinforce White supremacy, then "Whiteness" carries a significant measure of social and economic capital (see Crenshaw, 1995; C. Harris, 1993; Lareau & Horvat, 1999; Ledesma & Calderón, 2015). Using CRT as a framework was useful because the inequities that had contributed to math underperformance of Black girls had frequently emerged from a continued approach to education—including institutional decisions, educator biases, and family-school relationship building—that favor a White, middle-class, abled, cis-gendered status quo (Anyon, 2005). Cultural reproduction and critical race frameworks together focused on the influence that racism and social capital had on students' sense of belonging in math classrooms and on their academic achievements.

Critical Race Theory

Derrick Bell, Alan Freeman, Richard Delgado, and others introduced CRT at a time when 1960s Civil Rights reforms had "stalled and were in many respects being rolled back" (Delgado & Stefancic, 2012, p. 4). Bell (1976a) wrote that although the civil rights movements had made some progressive changes, it also promoted a perspective that racism was a unique situation, rather than a pervasive element in both everyday life and at the level of the institution. CRT was built on radical feminism's ideas about the relationship between power and social roles (Crenshaw, 1988). Another salient influence on CRT was the critical legal studies' notion that law cases may have more than one valid outcome (Delgado & Stefancic, 2012). Critical legal researchers also questioned the legal system's role in perpetuating the American class structure (Crenshaw, 1988). CRT is a tool for examining the tension that exists between American ideals such as democracy and capitalism as they interact with social realities (Bell, 1995). CRT is situated in the understandings that (a) racial classification is socially, not biologically determined; (b) races are not constructed in isolation but in relation to other races; and (c) the social construct of race includes other social constructs like gender, class, and religion (Delgado & Stefancic, 2012). Three key tenets of CRT are that (a) racism is the status quo of our culture, (b) racism benefits those in power who consequently may not want to change the system, and (c) race is socially constructed (Delgado & Stefancic, 2012). Critical race theorists countered, "Positivist notions of neutral, colorblind inquiry that avoid or minimize the existence or importance of racial issues" (Vaught & Castagno, 2008, p. 96). Researchers have also used CRT as a tool to measure educational inequalities (Ladson-Billings & Tate, 2016).

Posner (1997) challenged the legitimacy of CRT, calling it a mode of thought that "turns its back on the Western tradition of rational inquiry, forswearing analysis for narrative (p. 42). CRT scholars have posited that such claims are designed to protect the privilege of dominant groups (Bell, 1976b; Crenshaw, 1995; Yosso, 2005). CRT has also drawn criticism from groups "who felt their gendered, classed, sexual, immigrant and language experiences and histories were being silenced" (Yosso, 2005, p. 72) by CRT's focus on race to the exclusion of other intersections of oppression. CRT has evolved in response to such criticisms, and theorists have continued to expand their perspectives to include racialized experiences as these have intersected with ethnicity, gender, and sexual orientation. In one example, Delgado and Stefancic (1997) used a CRT framework to analyze White identity and to define being White. Ledesma and Calderón (2015) worried that critical race scholars and scholarship might "become liable to fall prey to accusations of simple identity politics and conjecture" (p. 207). To maintain CRT's strength as an analytical tool, Crenshaw (1995) and Dixson and Rousseau (2005) recommended the use of the framework should be grounded in an understanding of CRT's legal roots.

Cultural Reproduction

Bourdieu (1986) defined economic capital as distributed through social or cultural capital. Social and cultural capital can be converted into economic capital (Bourdieu, 1986). If capital "is a force inscribed in the objectivity of things so that everything is not equally possible or impossible" (Bourdieu, 1986, p. 241), then the social structures that result from the distribution of different levels of capital will never be neutral (Bourdieu, 1986). Social capital includes resources linked to group membership, as well as accumulated cultural knowledge, abilities, and advantages that can be used to leverage educational success (Bourdieu, 1986). Researchers have also defined Whiteness as a form of capital, an asset, and a state of privilege (C. Harris, 1993; Lareau & Horvat, 1999).

Bourdieu and Passeron (1977) followed a cultural reproduction framework to examine how educational institution leaders might legitimize the transmission of cultural capital across generations, and subsequently support the reproduction of social inequities. Research that has shown support for a cultural reproduction framework includes the finding that student academic achievement correlates to parents' educational level as demonstrated through beliefs and specific education related practices (Eccles, 2005; Lareau, 2011). Parents' educational levels typically predict family socioeconomic status, neighborhood, and access to schools- all variables that influence academic achievement. For example, when parents graduate from high school, their children are more likely to succeed academically (Archer et al., 2015; Entwistle & Alexander, 1989; Leitch & Tangri, 1988).

Other researchers have contradicted or expanded Bourdieu's (1986) framework of cultural reproduction. DiMaggio (1982) agreed family background and children's high school grades might correlate but found the correlation weaker than Bourdieu had suggested. Other researchers noticed that the socialization of lower socioeconomic status children into high-status culture may increase cultural mobility and consequently reduce racial inequalities in schools (Kalmijn & Kraaykamp, 1996). Roksa and Potter (2011) found that student achievement might be influenced by participation in cultural events, which supported some aspects of cultural mobility. Others have criticized a common assumption that exposure to White, middle-class cultural norms aligns with academic achievement (Banks, 2015; Yosso, 2005). Though Jæger (2011) observed a correlation between cultural capital an academic achievement, the effect size was smaller than has been typically reported when controlled for unobserved variables. Like DiMaggio (1982), Jæger (2011) questioned how cultural capital is measured. Others indicated that institutional and legal changes contribute more to Black students' educational progress than cultural capital does (Kalmijn & Kraaykamp, 1996).

Cultural reproduction theory's shortcomings include a limited consideration of cultural capital's value in relation to its setting or context, a lack of clarification of the distinction between the possession and activation of cultural capital, and the contextualized ways that social actors negotiate cultural capital (Lareau & Horvat, 1999). Finally, there is a concern that a cultural reproduction framework reinforces a cultural deprivation paradigm where academic achievement involves educators helping students "acquire" culture (Banks, 2015). From this perspective, the idea of cultural reproduction aligns with a deficit thinking model of education. When educators view cultural differences as deficits or gaps to be filled with exposure to the "right" culture, one may question how diverse students succeed academically without a threat to their identity development process. Despite these criticisms, the cultural reproduction framework was a useful way to think about how social capital might limit or support math learning across generations.

Potential Underlying Causes and Factors Related to the POP

Though the research intervention was conducted at a traditional rather than at a Montessori school, the primary observations that drove the choice of an intervention occurred at PCM, a public charter Montessori school. To learn more about the factors influencing math learning at PCM, the author examined Montessori pedagogical strategies, as these aligned with best learning practices as indicated in the literature for Black female students. These findings were not directly applicable to research conducted at CPS; however, pedagogical implications on math learning were relevant to both educational contexts. An examination of race and gender as these relate to math learning is included in this chapter. Finally, factors discussed as potential drivers of math underperformance of Black girls at PCM include (a) teacher perception rooted in bias, (b) identity constructs as these support students' sense of self as math scholars, (c) institutional legitimization of Black parents' cultural capital, and (d) collaboration between school and families.

Gender and Math Learning

In this research, *sex* refers to "the anatomical and physiological distinctions between men and women," and *gender* refers to "the cultural overlay on those anatomical and physiological distinctions" (M. Case, 1995, p. 12). Societal expectations and gender roles are typically assigned based on biological sex, and these often dictate girls' and women's access to institutional, social, and cultural power. For the last half-century, a continuum of federal policies, beginning with the Civil Rights Act (1964), have mandated social change through prohibiting discrimination in federally funded programs based on different social identity characteristics, including race, sex, national origin, and ability. A brief history of the shift of institutional priorities over time and with feedback from constituents follows a brief discussion of some of the barriers faced by girls in mathematics classes.

Though 70% of women worldwide prefer to work at paid jobs, only 49% work at such jobs. These female workers are more likely to work “in low-quality jobs in vulnerable conditions, and there is little improvement forecast in the near future” (International Labour Organization, 2019, para. 2). Considering STEM careers, Black women are underrepresented (Tyler-Wood, Ellison, Lim, & Periathiruvadi, 2012; Zeldin & Pajares, 2000). A slight increase of Black women earning degrees in STEM fields has generated few mathematicians (Borum & Walker, 2012; Perna et al., 2009), and the attrition rate among Black, female doctoral math candidates is disproportionately high compared to other groups (Herzig, 2004). Despite representing over 20% of the overall American population (U.S. Census Bureau, 2009, 2010), women of color earned only 12% of the STEM degrees that year (Espinosa, 2011; National Science Foundation, 2009). In 2015, Black women earned 66% of the bachelor’s degrees earned by Black people, but only 10% of the engineering degrees, 31% of the degrees in natural sciences (National Science Foundation, 2018). Women are underrepresented in certain high-paying jobs including those in STEM fields. Reasons for this underrepresentation are complex, but one contributing factor is gender bias (Nimmesgern, 2016).

Gender bias in educational institutions continues to limit expectations and opportunities for girls in the United States and other parts of the world (Burton, 1990; Li, 1999; Riegle-Crumb & Humphries, 2012). Some researcher have justified a perception that females are intellectually inferior to males, especially in math and science related subjects, with biology (Bianco, Garrison-Wade, & Leech, 2011; Browne, 2004). Some 19th-century scientists argued the relatively smaller brains of women compared to men indicated an inferior intelligence (Vidal, 2012). More recently, scientists have studied gender-based brain differences to learn if they determine male and female performances at specific tasks; King and Gurian (2006) summarized structural differences between male and female brains, including that (a) males have denser spatial-mechanical cortical areas, while females' cortexes are thicker in areas associated with language; (b) girls' frontal lobe develops earlier than boys and remains more active; and (c) females tend to draw on both hemispheres more often than males making females more able to multi-task. S. S. Case and Oetama-Paul (2015) described females as having denser neural cortical matter in the planum temporale, an area of the brain tied to language and listening, while male brains are lateralized, which leads to more focused analytical thinking. Such findings have been used as neurological evidence that boys are wired to excel at math, while girls are more oriented toward language learning.

Data has shown that boys' average advanced placement test scores on calculus, computer science, and science are higher than girls, while girls tend to do better on reading and writing tests (Freeman, 2004). Benbow and Stanley (1980) interpreted data that showed males outperforming females when both groups had similar training as support for the idea that males have superior innate math ability compared to females. They hypothesized that females take fewer math classes than males because they are not as good at math (Benbow & Stanley, 1980). Eccles and Jacobs (1986) contradicted Benbow and Stanley's (1980) study by observing that math outcomes reflected noncognitive, rather than aptitude differences. Noncognitive variables include math students' endorsement of their parents' gender-related beliefs about math (Casad, Hale, & Wachs, 2015; Engelhard, 1990; Wang & Degol, 2017), teachers' gender related anxiety about math learning (Beilock, Gunderson, Ramirez, & Levine, 2010), a lack of female role models (Jones, 1993), or low student self-efficacy related to math learning (Zeldin & Pajares, 2000). Other evidence has shown the gender gap narrowing and attributes the lower participation of females in STEM jobs to a gap in their perception of science careers rather than in ability (Tyler-Wood et al., 2012).

Joel (2011) hypothesized that brains are not limited to one gender but are more like mosaics—with features that change from masculine to feminine as needed. Further, the brain's neuroplasticity allows it to adjust to sociocultural contexts (S. S. Case & Oetama-Paul, 2015). Attributing both neurological and experiential factors to cognitive growth, S. S. Case and Oetama-Paul (2015) wrote, "Both experiential and social learning impact the brain and behavioral functioning, making it difficult to separate the relative contributions of each" (p. 347).

Federal Policy Supporting Educational Equity for Girls

As the United States approached its 200th birthday, the U.S. Congress passed the Civil Rights Act (1964), which legislated the desegregation of public education, public accommodations, public facilities, in federally funded public programs based on "color, race, religion, or national origin" (para. 4). The Civil Rights Act (1964) gained prominence before policy makers at this time in U.S. history because of sustained visibility of and pressure by activists operating outside of the government. U.S. Congress voted to insert sex into the categories protected from discrimination in Title VII, which gave women workplace protections including general protections against sexual harassment. The Educational Act's Title IX (1972) expanded these protections.

Title IX. Title IX is part of the Education Act (1972), which addresses civil rights issues in educational contexts. Coauthored by Senator Birch Bayh and House Representative Patsy Mink, Title IX eventually increased equity in schools by (a) allowing girls to attend class while pregnant, (b) giving girls and boys access to the same classes, (c) maintaining the same requirements for boys and girls in a class, and (d) establishing equal budgets for boys' and girls' activities (Flansburg & Hanson, 1993). Change was mandated on both local and state levels. Originally, the U.S. Supreme Court interpreted Title IX narrowly, specifying that it applied only to specific programs. Protections against sexual harassment excluded student to student interactions until the 1999 Supreme Court case, *Davis v. Monroe County Board of Education* found that a school is liable for damages when the following conditions are met: (a) a student sexually harasses another student, (b) a school administrator with sufficient power to address the abuse knows what happened, and (c) the administrator willfully does not act to protect the student (Lave, 2016; U.S. Department of Education, 2001).

Title IX became the standard used by institutions of higher education to investigate harassment accusations. Title IX was revised in 1997, and again in 2001 when guidance was given to help institutions recognize “that sexual harassment has occurred and to take prompt and effective action calculated to end the harassment, prevent its recurrence, and, as appropriate, remedy its effects” (U.S. Department of Education, 2001, p. iii). However, many schools’ interpretation of sexual harassment did not include rape, sexual violence, or peer-to-peer interactions (Carroll et al., 2013). Karjane, Fischer, and Cullen (1999) surveyed 25,000 higher learning institutions and found many schools did not have sexual assault policies. In 2011, The Obama-era Dear Colleague Letter (DCL) was organized around the problem of noncompliance with Title IX guidelines (Ali, 2011). The Officer for Civil Rights found 250 institutions of higher education as not in compliance with federal law “which demands that students are not denied the ability to participate fully in educational and other opportunities due to sex” (U.S. Department of Education, 2017, p. iii). Trump era Secretary of Education, DeVos’ Interim Guidance (2017) narrowed the definition of sexual harassment and established a higher legal standard for a victim to prove harassment.

Sexual assault policy in elementary school. This federal policy is relevant to all students, including the fourth-grade girls addressed by this study. A study by the University of Illinois at Urbana-Champaign said that 21% of middle-school students have been touched inappropriately while at school (Fritze, 2017). Maryland public K-12 schools, students reported 4,587 incidents of harassment or bullying. Of these, 70.1% involved teasing or threats, and 43.9% involved physical attacks (Chandler, 2018). At the same time, schools do not reliably protect students from or report incidents of sexual harassment or violence (Chandler, 2018). These lackluster responses are standard even in states that are more progressive about sexual assault policy (Chandler, 2018).

Relevance of the Dear Colleague Letter to learning math. Ali (2011) wrote the following in the DCL:

> Education has long been recognized as the great equalizer in America. The U.S. Department of Education and its Office for Civil Rights (OCR) believe that providing all students with an educational environment free from discrimination is extremely important. The sexual harassment of students, including sexual violence, interferes with students' right to receive an education free from discrimination and, in the case of sexual violence, is a crime. (para. 1)

At schools, harassment occurs in public.

> This public enactment of sexual harassment may have more damaging ramifications than harassment that happens in private because of the potential for public humiliation, the damage to one's reputation, the rumors targets must fear and combat, and the strategies that the targets implement in an effort to reduce or avoid the encounters. When sexual harassment occurs in public and is not condemned, it becomes, with time, part of the social norm. (Stein, 1995, p. 147)

It may happen on campus, off campus, or online; either way, the effect is damaging to children's ability to learn. Students who experience sexual harassment or assault "face potential traumatization—the shattering of their trust in their ability to make sound judgments about the people and the world around them—at an important stage in their development. The cost of this potential loss is inestimable" (Karjane et al., 1999, p. 20). Another effect of sexual assault can be declining academic interest and performance (Brodsky, 2016; Hansen et al., 2018; Karjane et al., 1999). The relevance of policies like the DCL and the interim guidance is these may shift the culture for an entire generation, time, and space. Higher education policy influences the wider cultural climate that informs culture at the elementary school level.

Math Learning Related to Race

Throughout American history, the opportunities for education afforded to Black children have been arbitrary, substandard, or inconsistent; White people have wielded what Ladson-Billings and Tate (2016) referred to as the "absolute right to refuse" (p. 14) equal education to Black children. Consequently, many Black people have not had the opportunity to develop cultural capital in relation to institutional math learning (Archer et al., 2015; Berry, 2008; Lareau, 2011). Racism has undermined, and continues to undermine, Black children's access to equitable education (Parsons & Turner, 2014).

During the Colonial American period, enslaved people were sometimes taught to read— and less frequently to write— so that they could read the Bible or help their owner with business related tasks (Cornelius, 1983). However, following the Stono Rebellion, a slave uprising in South Carolina in 1739, South Carolina enacted the first state code forbidding the education of enslaved persons (Mitchell, 2008; Rasmussen, 2010)—other southern states followed South Carolina's lead. During the early 19th-century, the 1831 uprising led by Nat Turner and an increase of abolitionist literature frightened White people in different southern states into passing codes that restricted Black people's education (Mitchell, 2008). The governments of most southern states (exceptions were Kentucky and Maryland) instituted anti-literacy laws that made reading and writing illegal for both enslaved and free Black people (Cornelius, 1983; A. Y. Davis, 2011). Although, on occasion, members of the plantation owner's family (most often the children) taught enslaved people how to read and write, literacy was not a basic right of enslaved people (Cohen, Cohen, & White, 2012; Mitchell, 2008). Mitchell (2008) found that slaves, often at great risk, often taught themselves or others including the establishment of "Sabbath schools to increase clandestine literacy efforts" (p. 87).

During the American Civil War and through reconstruction, Freedmen's Aid Societies, mostly from the North, worked to meet the "religious and educational needs of the Black and White refugees" (Jackson, 2000, p. 3). After the war, literate formerly enslaved people opened schools that helped Black children to make significant academic gains (Cornelius, 1983; Parsons & Turner, 2014; Pellegrino, Mann, & Russell, 2013; Tyack & Lowe, 1986). Missionaries or freedmen's societies ran other schools (McPherson, 1970), where approximately three-fourths of the teachers and administrators were White. Francis Grimké said that "the intellects of our young people are being educated at the expense of their manhood. In the classroom they see only White professors," which leads them "to associate these places and the idea of fitness for them only with White men" (as cited by McPherson, 1970, p. 1362). Freedmen's societies operated schools for Black children in the South and existed through the 1870s when most were absorbed by new public-school systems.

In the Civil Rights Act of 1883, the U.S. Supreme Court found the Civil Rights Act of 1875, which prohibited race-based discrimination in public places, unconstitutional and they tested the federal government's right to interfere with private-sector decisions about race, which resulted in public funding cuts for Black schools (Bradley & U.S. Supreme Court, 1883; Parsons & Turner, 2014; Pellegrino et al., 2013). Soon after, the U.S. Supreme Court case, *Plessy vs. Ferguson* (U.S. Supreme Court, 1896), made separate but equal the law that would reinforce the constitutionality of Jim Crow laws and drive a segregated educational system. Justice Henry Brown, in the majority opinion, found the plaintiff's argument unsound based on its "assumption that the enforced separation of the two races stamps the colored race with a badge of inferiority. If this be so, it is not by reason of anything found in the act, but solely because the colored race chooses to put that construction upon it" (as cited by Kousser, 1980, p. 17).

Yet, evidence at the time clearly showed conditions were not equal for Black and White Americans. Menand (2019) wrote the following:

> The assumption that separate facilities for Blacks—railroad cars, steamboat Berths, schools—were not inferior is a good example of the Supreme Court's Formalism in that period of American law. Everyone knew that the Assumption was false. The Jim Crow train car was sometimes called "the dirt car," and "colored" schools were often shacks. It was also absurd to claim that the "badge of inferiority" was a Black person's construction. (p. 16)

Margo (1986) studied student achievement in Alabama from 1920 to 1940 to show an inequality in educational inputs for students by race. The data showed instructional expenditures per student per day was more than twice as high for White children compared to Black children. White children also benefited from a longer school year, more teachers, and a higher value of school capital. Separate but equal proved to be a myth across the South where White children consistently had better schools and resources than Black children (Kousser, 1980; Walker, 2000). Though data showing the monetary value of educational inputs does not fully account for the learning communities that often developed despite these inequalities, they do indicate that an allocation of resources favored White, and not Black children (Walker, 2000). Margo (1986) predicted, "Strict enforcement of the Supreme Court's 1896 separate-but-equal ruling, particularly with respect to the length of the school year, would have narrowed the literacy gap between White and Black children" (p. 800). However, Margo (1986) posited, "Only a radical redistribution of school board budgets would have compensated for the poverty and adult illiteracy that hindered Black school achievement in the early twentieth-century South" (p. 800).

The U.S. Supreme Court determined that racial segregation was constitutional if facilities were "equal in quality." In response to an inequitable disbursement of educational funding, the Black community established and financially supported many of their own schools (Aaronson & Mazumder, 2011; Pellegrino et al., 2013; Tyack & Lowe, 1986). However, poverty, illiteracy, and lack of political representation, especially in the rural south, undermined efforts to provide school for all Black children (Aaronson & Mazumder, 2011; Tyack & Lowe, 1986). The U.S. Supreme Court decision, *Brown vs. the Board of Education in Topeka, Kansas* (1954) reversed the "color-blind" interpretation of the U.S. Constitution from *Plessy vs. Ferguson* (1896) determining "that legal segregation of public accommodations, including de jure segregation of educational institutions, was unconstitutional" (Parsons & Turner, 2014, p. 99).

Despite the passage of *Brown vs. the Board* (1954), many school district leaders resisted integration by refusing outright to participate, or through de facto segregation, leaders supported by redlining policies used to maintain neighborhood segregation (Pietila, 2012; D. A. Smith, 1976; J. J. Smith & Stovall, 2008). The Supreme Court in *Milliken v. Bradley* (1974) chose to not address the impact of residential segregation on schools in Detroit and its suburbs. Finding no deliberate attempt by the school district to promote desegregation, the Supreme Court did not hold the state responsible for integrating students across district lines (D. A. Smith, 1976). This decision accelerated the hyper-segregation of schools in inner cities—including the city where this intervention occurred—across the United States (D. A. Smith, 1976).

In districts where schools with all Black children were closed and students transferred to formerly White schools, Black teachers were fired en masse. This mass firing fostered an underrepresentation of Black teachers compared to Black students in the newly integrated schools. Too often, Black children's intellectual abilities were doubted or underestimated by predominantly White teachers and administrators (hooks, 2014; Snipes & Waters, 2005). Hooks (2014) wrote, "When we entered racist, desegregated White schools we left a world where teachers believed that to educate Black children rightly would require a political commitment. Now we were mainly taught by White teachers whose lessons reinforced racist stereotypes" (p. 3).

This underrepresentation of non-White teachers continues today in the United States, with an 18% population of teachers of color serving a K-12 population, where 49% of the students are Black or Brown (U.S. Department of Education, 2016). Some inconclusive evidence has shown school integration is a factor that decreases persistent racial academic achievement gaps (U.S. Department of Education, 2016). Barton and Coley (2010) considered underlying factors to explain a narrowing of the achievement gap from the 1970s to the late 1980s. They noticed large gains in both desegregation and academic achievement in some southern regions but could not count desegregation as a variable due to significant differences in each district's achievement (Rothstein, 2015).

Critical race scholar and lawyer, Bell (1976a) questioned integration's role in helping Black children gain an equal footing in schools saying that school desegregation "fails to encompass the complexity of achieving equal educational opportunities for children to whom it has so long been denied" (p. 7). Though the right to associate with diverse ethnic and racial groups was an important outcome of the Civil Rights Movement, Bell (1976a) reminded that educational support for Black children should not be limited to desegregation. School desegregation did open new opportunities for some Black children; however, a systemic conflation of "good education" with desegregation has perpetuated an educational system that in many cases reinforces discrimination, prejudice, and poverty (Bell, 1976a; Crenshaw, 1995; Ladson-Billings, 1995). First, "good education" becomes synonymous with "White education" (Bell, 1976b) or with the educational perspective of the status quo majority. Second, a widespread public belief that the educational system is objective leads to an assumption that the system is a color-blind meritocracy (Crenshaw, 1995). Third, when children do not perform well by the "objective" standards, they or their families are either deficient or at fault (Ladson-Billings, 1995).

Today, in many cases, American schools have resegregated by race, socioeconomic status, and language (A. Y. Davis, 2011; Ferri & Connor, 2005; Orfield, Bachmeier, James, & Eitle, 1997; Wilson, 2016). Separate and unequal schooling continues as the norm in American public education, where math score gaps between Black and White children often increase over the course of elementary school (Quinn, 2015). Academic tracking policies and school choice are common tactics for reinforcing racial inequality within schools (Ladson-Billings & Tate, 2016).

PCM, where the needs assessment occurred, was a charter school that had 10% of its population from its predominantly Black, low socioeconomic, but gentrifying neighborhood. Students were chosen by lottery from communities across the city. In a city where many schools were hyper-segregated, PCM had a population with a similar number of Black and White students. Though racially and socioeconomically integrated, within-school, race-based disparity on math scores indicated all children might not have equal access to institutional resources.

CPS, where the research intervention was situated, had a largely White population: 27% of the students were Black, 68% were White, and 4% and 3% were Hispanic and Asian, respectively. In a city where many schools were segregated with only Black students, CPS's neighborhood, Waterstown (a pseudonym), reflected the impact of decades of legal and de facto segregation policies on the neighborhood composition and subsequent school demographics in a Mid-Atlantic city. Waterstown was a historically White, working-class neighborhood. Practices including redlining ensured Waterstown had remained a segregated community for many years; today, 85% of its inhabitants are White.

Intersection of Race and Gender

Crenshaw (1989) cautioned against treating race and gender as "mutually exclusive categories of experience and analysis" (p. 139), but few researchers explored the intersection of institutional oppressions that contextualize math learning for Black girls. Many research studies focused on how gender (Benbow & Stanley, 1980; Eccles & Jacobs, 1986; Naizer, Hawthorn, & Henley, 2014; Usher, 2009) or race (Archer et al., 2015; Chavous, Rivas-Drake, Smalls, Griffin, & Cogburn, 2008; Entwhistle & Alexander, 1989) influence learning. A growing number of authors' observations of the intersection between race and gender show the learning experiences of Black girls; however, Black girls' academic achievement is often studied in relation to other demographic groups, or in relation to issues such as teen pregnancy or violence (Chavous & Cogburn, 2007). Many teachers' perceptions of Black learners do not consider the varied contexts of these children's lives (Ford, 2015). Other studies of Black girls conflate race and socioeconomic status (Scott-Jones & Clark, 1986). The need for research to address the learning experience of Black girls was evident. The intent of this literature review was to explore factors that might undermine the academic achievement of Black girls in relation to their own math learning potential.

Synthesis of Research Literature Related to Underlying Factors

The Montessori Method

The Montessori method was a child-centered learning approach based on Maria Montessori's (2017) pedagogical philosophy. Key characteristics of a traditional Montessori learning context—developmental planes, sensorial learning, socially-constructed learning, and self-directed learning—are described below. Next, an overview of Montessori education in the public sector is provided. Finally, the researcher describes the alignment between the Montessori teaching method and pedagogical strategies shown by the literature to support academic achievement of Black girls.

Four planes of development. Maria Montessori's (1917) developmental stage model emerged through her working observations of children. These observations informed Montessori's (1917) categorization of childhood into four 6-year planes of development. Each of the four planes is cognitively, socially, physically, and emotionally distinct from other developmental planes. Montessori believed that sensitive periods for different learning tasks are tied to the child's age-related developmental stage. Though comparable to Piaget's stages of development (see Inhelder & Piaget, 1958), the educator's models differ. Montessori (1917) believed children should be exposed to a wide range of tasks at all stages of development. Unlike

Inhelder and Piaget (1958) who encouraged reading only after children reached the cognitive stage, Montessori exposed children to reading much earlier.

PCM children observed for this needs' assessment were in what Montessori called the *second plane of development*. Montessori noticed children transitioning from the first plane (0-6 years) to the second (7-12 year) became more capable of working with abstract concepts. Second plane children are increasingly able to use their imaginations to solve problems or to analyze complex moral situations. Montessori (1917, 1948/1994) wrote that children in the first plane use new knowledge to better negotiate their physical surroundings. Because children in the second plane (7-12) are already competent actors within their day to day environments, they expand their cognitive focus to negotiate interactions within different social structures (Duffy & Duffy, 2002; Montessori, 1948/1994). Second plane children seek to understand existential questions, especially how they fit into various frameworks of existence (biological, moral, historical, etc.). To support this need, the Montessori pedagogy situates learning within three questions that make curricular content relevant to the elementary age child: How did I get here? Who am I? What is my cosmic purpose? (Duffy & Duffy, 2002). Content lessons in all curricular areas are structured around these questions (Duffy & Duffy, 2002; Montessori, 1948/1994).

Sensorial learning. Influenced by Rousseau's (1762) emphasis on learning through sensory exploration, and the evaluation of personal experience, Montessori educators rely on sensorial and hands-on experiences as a bridge to learning abstract concepts. For example, sensorial materials support a child's transition from concrete to abstract arithmetic operation. A beginning learner may solve addition problems with the golden beads, a Montessori material that offers one-to-one object representation (Montessori, 1917). The golden bead work allows students to observe the difference in size and weight between numbers; for example, a unit bead is much lighter and smaller than a 1,000 cube. Once a student masters that work, they can bridge to a more abstract work, the stamp game, where numbers are represented by identically sized tiles distinguished only by color. From the stamp game, students transition to the bead frame, and eventually to abstract arithmetic operations (Montessori, 1917). Montessori math materials are designed to scaffold student progress from concrete to abstract operations for math skills including counting, long division, and finding binomial square roots (Montessori, 1917, 1949/1995).

Socioculturally constructed learning. Like Vygotsky (1986), Montessori (1949/1995) held that cognitive growth is coconstructed within social spaces; however, unlike Vygotsky (1986), Montessori (1949/1995) believed that learners could construct cognitive growth through their independent relationship with the work. Thus, Montessori learners construct knowledge independently as well as in collaboration with mixed-age peers, adults, and the prepared environment (Bodrova, 2003; Montessori, 1917, 1949/1995). Within the social learning environment, children coconstruct cognitive understanding and apply innovative approaches to classroom tasks (Bandura, 1977). An emphasis on peer work gives students many opportunities to play both the mentor and novice role in learning. Community is a salient feature of Montessori classrooms. Community meetings and decision-making are key classroom management strategies.

Self-directed learning. With an emphasis on continual, intrinsically driven improvement, student work is typically not graded (Montessori 1917, 1995). Montessori relies on intrinsic motivation or the idea put forth by Bandura that “prior notions guide the learner more than performance “(Bandura, 1977, p. 35). As children develop the ability to regulate their own work and behaviors, they take on the responsibility of supporting peers and maintaining classroom systems. The teacher’s role is to prepare students to become capable of regulating and maintaining balance between freedom of choice and responsibilities within the learning community. Though emphasis is placed on students working independently to refine their work, they are tasked in an environment where intrinsic motivation and collaboration are valued over extrinsic competition.

Public Montessori Schools

The Montessori method of teaching was Maria Montessori's solution for the problem of educating children in marginalized communities including a slum in Rome, and a State Orthophrenic School, also in Rome, attended by the "hopelessly deficient" or "idiot-children" with low cognitive levels (Standing, 1957). Since its inception in 1907, Montessori education has become more elite. Most Montessori schools in the United States are private, and these attract a predominantly mainstream, White, middle-class cohort. Public Montessori Schools were developed in the 1970s as an initiative for White families to desegregate city schools in Cincinnati, Ohio and other urban centers (Debs, 2015). This continuing trend toward public, often urban, Montessori schools has prompted some discussion about whether the traditional vision of Montessori schools sufficiently meets the needs of a diverse, urban population. Empirical research on this topic is limited and nonconclusive.

A short-term study of kindergarten students found that Black children make greater gains in traditional as compared to Montessori programs; however, the public Montessori studies did not have multi-aged classrooms as would a traditional Montessori program (Ansari & Winsler, 2014). Lopata, Wallace, and Finn (2005) also did not find that Montessori education offered an academic advantage. Montessori eighth grade students studied by Lopata et al. (2005) scored lower than students from the control group. No data were collected on race or gender. By contrast, a longitudinal study of low-income, public Montessori elementary students within the Milwaukee Public School system showed that Montessori students who attended from ages 3 to 11 outperformed those in a non-Montessori control group on high school science, technology, and math standardized test scores. No data were collected about ethnicity or gender (Dohrmann, Nishida, Gartner, Lipsky, & Grimm, 2007). As a follow-up to the Milwaukee study, Lillard and

Else-Quest (2006) studied 112 children from families with comparable incomes. Students were not selected for race, but most were Black. Because Milwaukee Public Montessori students are chosen by lottery, Lillard and Else-Quest controlled for parent influence by choosing families who had lost the lottery to be the control group. They found that Montessori kindergarteners had higher Woodcock Johnson test scores, as well as a higher rate of reasoning on social problem-solving tasks when compared to the control. The older Montessori students performed as well as the control on skills tests; however, their writing was more highly developed than the control (Lillard & Else-Quest, 2006).

Several researchers found Montessori students were stronger at social problem solving than those from other learning environments (Ansari & Winsler, 2014; Dohrmann et al., 2007; Lillard & Quest, 2006), but one researcher group observed no social or academic gains (Lopata et al., 2005). One possible factor driving math underperformance of Black girls at PCM might be an inadequate fit between students and the Montessori method. Research literature has determined several pedagogical strategies to support academic achievement for Black children. These strategies are compared to Montessori based strategies currently used at PCM. First, the Montessori context for this research study is described.

Montessori Context

This study was contextualized in a Montessori public charter school in an urban, Mid-Atlantic region of the United States. PCM teachers must provide a Montessori learning environment and comply with institutional requirements set forth by the city and state. Where private Montessori schools would decide independently whether to administer standardized tests, PCM followed city-school testing mandates. Required assessments included the PARCC, a common core based assessment. Students must also meet an individualized student learning objective (SLO). The SLO would measure student growth in one academic area over the course of the school year. One consequence of administering these mandated assessments was that unlike private Montessori schools, public Montessori schools must dedicate considerable time and other resources to high-stakes testing.

The Montessori public charter school, where the needs assessment for this research occurred, offered more racial, ethnic, and socioeconomic diversity than most private Montessori schools. Another difference between public and private Montessori schools is the typical age when students enter the school. In many Montessori schools, students typically stay in the program from prekindergarten to completion. By contrast public charter students may join the school in upper-elementary school or even later. Students are chosen to attend PCM through a lottery system. Though selection is random, parents must apply for the program. Parent initiative to apply for an alternative educational program may align with parental practices that support early childhood preparation for school. When students leave the school, new students are chosen through the lottery to take their place. PCM consistently has a waitlist of more than 1,000 potential students, according to anecdotal sources within the school's administration.

When students enter the Montessori system in upper-elementary, the stress level in individual classrooms at PCM increases, according to several teachers at that school. In Montessori classrooms, students coconstruct learning experiences, as well as the classroom culture and norms. Students can play the roles of both mentor and novice during the socially-constructed learning process (see Montessori, 1917). Children are supposed to support or redirect their peers to a more appropriate path as needed. When a large number of students are unfamiliar with the Montessori norms and behavioral expectations, typically introduced beginning in prekindergarten, the classroom has fewer students to give help and more who need help. An additional challenge for new students is adjusting to interactions in an environment where they must negotiate a balance between personal freedom and community responsibility (see Montessori, 1917). Anecdotally, according to private conversations with several PCM teachers, transitioning to Montessori takes new students at least a year.

Montessori and Cultural Responsiveness

In theory, Montessori aligns well with culturally responsive pedagogy. Culturally responsive pedagogy is defined as a transformative, student-centered pedagogy that incorporates the ecological situations and identities of learners (Gay, 2000). Culturally responsive pedagogy does not prescribe a specific scope and sequence of lessons. However, principals promote equity in different spheres of the child's education: "(a) teacher learning, (b) student learning, (c) intergroup relations, (d) school governance, organization, and equity, and (e) assessment" (Banks et al., 2001, p. 196).

Both pedagogies have sociocultural foundations that encourage child-centered, collaborative learning (Gay, 2002; Ladson-Billings, 1995; Montessori, 1917). The Montessori philosophy and curriculum are tightly aligned, which facilitates the consistent integration of a multicultural perspective. Montessori's work was informed by observations of ethnically, cognitively, and socioeconomically diverse children; her philosophy and curriculum are rooted in those observations. Gay's (2002) ideas about the formal, symbolic, and social curricula are integrated in the typical Montessori classroom, where emphasis on group work, community, and peace education shows high cultural congruity.

Despite efforts at the school level to provide all students with a certain standard of Montessori education, achievement gaps persist. Some assume that standardized education guarantees each student an equal "opportunity to store this information in their heads; that is, to 'learn it'" (Gee, 2008, p. 76). When students do not learn, "The students, not the techniques are found to be lacking" (Ladson-Billings, 1998, p. 20). In line with a belief that our educational system is neutral and objective, some scholars have determined that between-group test score disparities reflect innate group ability (Gordon, 1995; Herrnstein & Murray, 2010; Jensen, 1974). However, Au (2014) described the objectivity of standardized testing as "assumptive objectivity" used to "justify educational systems that mainly reproduced extant socioeconomic inequalities"

(p. 10). Test scores have been used to justify tracking Black students into low-level classes, or limiting their participation in gifted programs (Au, 2014; Ford, 2015; Moses & Cobb, 2001). Even when tests are administered objectively, they may not objectively measure student ability or desire to learn. Thus, education is not an equal playing field. Even when exposed to the same curriculum and learning environment, different children may not have the same opportunity to learn (Bell, 1976b; Gee, 2008; Gibson, 1977; Lleras, 2008). In the following section, different pedagogical strategies are examined in relation to their success at supporting learning for Black girls.

Pedagogical Strategies

Pedagogical strategies are discussed in relation to their success with fostering strong math outcomes with Black learners (Baker, Gersten, & Lee, 2002; Cobb & Bowers, 1999; Gutierrez, 2000; Ladson-Billings, 1998; Lopata et al., 2005; Love & Kruger, 2005; MacNeil, 2014; Tyler-Wood et al., 2012; Resnick, 1987; Van Voorhis, 2011; Yull, Blitz, Thompson, & Murray, 2014) and girls (Tyler-Wood et al., 2012). There was a limit to empirical evidence showing an intersection of race and gender might affect math learning for the target group; however, an overview of strategies that support learning for Black students was available and included (a) giving learners and teachers formative feedback, (b) using peer tutors, (c) giving parents specific feedback on children's math performances, and (d) balancing open-ended explicit instruction with problem solving (Baker et al., 2002). Successful strategies included traditional pedagogy (Love & Kruger, 2005; Lopata, et al., 2005), high expectations (Gutierrez, 2000; MacNeil, 2014), instilling a sense of community in the classroom (Ladson-Billings, 1998; Yull et al., 2014), and flexible teaching support academic achievement for Black students in an urban context (Love & Kruger, 2005). The literature also showed that situating learning in everyday experience supported academic achievement for Black children (Cobb & Bowers, 1999; Moses & Cobb, 2001; Tyler-Wood et al., 2012; Resnick, 1987; Tomlinson, 2000; Van Voorhis, 2011).

Martin (2012) emphasized important aspects of math learning for teachers of Black children to consider, including the following:

> (a) the racialized nature of students' mathematical experiences in school and non-school settings, (b) students' beliefs about their ability to participate meaningfully in mathematical contexts based on their socializing experiences, (c) their resulting motivations and rationales for learning and doing mathematics, and (d) the coconstruction of mathematics identities and other social identities that are important to these students. (p. 49)

Tyler-Wood et al. (2011) suggested supporting female math scholars by (a) incorporating verbal skills into STEM classes, (b) making math lessons challenging, and hands-on, (c) encouraging a mastery, rather than a performance mindset in female learners, (d) giving prescriptive formative feedback, and (e) teaching spatial skills. R. Gutiérrez (2000) found students grow when curriculum is culturally relevant, and when teachers acknowledge student confidence. Her research showed strategies at the level of the department that correlate with Black students' academic achievement include rigorous curriculum, teacher commitment and responsiveness to students, shared department goals, support from department leaders, teacher innovation with curriculum.

Montessori and Black Female Learners

None of the pedagogical strategies above are antithetical to the Montessori method, even those that Montessori does not explicitly refer to could be incorporated into a Montessori classroom. For example, Maria Montessori did not talk write or lecture about the "coconstruction of mathematics identities, and other social identities" (Martin, 2012, p. 49), but these concepts do align with the Montessori education. At PCM, not pedagogy but implicit bias is more likely to undermine Black girls' access to education. Decisions, actions, and beliefs informed by implicit attitudes about race and gender may undermine the ability of White teachers, even those committed to equity, to teach Black girls (Ladson-Billings & Tate, 2016). Black girls may experience microaggressions of racism and sexism, which add stress to the learning experience (Yull et al., 2014).

Private correspondences with the head of school revealed that PCM had attempted to reduce bias and increase equity. The school increased the number of non-White teachers and administrators. PCM had an equity audit that requires teachers to participate in a long-term professional development on equity. However, based on anecdotal observation, this work would remain ongoing, and teacher commitment might vary across classrooms.

Teacher Perception

Researchers have examined how implicit bias or unconscious attitudes about race, gender, and socioeconomic class drives behaviors, shapes teachers' expectations of student performance, and informs teacher decision making (Ghoshal, Lippard, Ribas, & Muir, 2013; Staats, 2016). Substantial evidence has shown that teachers' perceptions often determine student access to educational opportunity (Bianco et al., 2011; Gholson & Martin, 2014; Francis, 2012; West-Olatunji et al., 2010). Opportunities may be limited at the level of the student-teacher relationship, or by the larger educational system. Kenyon (1980) observed the relationship between student learning and socioeconomic class. They found that schools serving working class students gave students less decision-making power and more rote memorization tasks than schools that served upper-middle class students. Studies have shown a discrepancy in the quality of attention given to Black and White students (Hillman & Davenport, 1978; Scott-Jones & Clark, 1986). Children are typically sensitive to teachers' beliefs about them as math learners. Individual teacher beliefs correlate with student interest and outcome; consequently, a teacher's race or gender-stereotypic beliefs and actions may lead to a decreased interest in math for Black girls (Upadyaya & Eccles, 2014). Espinoza, da Luz Fontes, and Arms-Chavez (2014) found that teachers demonstrated attributional bias based on gender even after coaching. Espinoza et al.

designed a measure of attributional bias and used it to collect baseline measures of bias for 20 middle-school, and high school math teachers at a 3-hour workshop where problems in math teaching were addressed. As predicted by the researchers, teachers attributed boys' math success to ability and girls' success to effort. Conversely, boys' math failures were attributed to lack of effort, and girls were attributed to lack of ability (Espinoza et al., 2014). If teacher bias is a strong determinant of how attentional resources are distributed in the classroom, Black girls at PCM are unlikely to receive an equitable share of attention.

Social Identity Constructs

Social identities are "that part of the individual's self-concept that is derived from their knowledge of their membership of a social group (or groups) together with the value and emotional significance of that membership" (Tajfel, 1981, p. 255). Social identity theory assumes that members of the same group will favor one another and depersonalize those outside of the group (Tajfel, 1982). Individuals typically belong to several social identity groups. These identities interact with an individual's personal characteristics to determine his or her position in relation to social and institutional structures. Black girls are positioned at the intersection of at least three oppressions: gender, race, and age. However, personal characteristics, environment, and other factors mediate the experience of individual girls. Below, a brief discussion of Black and female identities demonstrate the variance within identity groups.

Several models have been used to describe the process of "becoming Black" (Cross, 1978). Thomas (1971) described a process through which an individual might transition from negromachy, a condition characterized by "confusion of self-worth" to self-determination (Cross, 1978). Cross's (1991) model of Nigrescence[1] comprises five statuses or mindsets related to an individual's emerging sense of Black identity: (a) preencounter or the stage before the individual

[1] Typically, theories are not capitalized in APA format. Nigrescense here means Black which is capitalized in APA, hence Nigrescence is capitalized here.

is aware of their race, (b) encounter or the stage when the individual has an experience that heightens racial awareness; (c) immersion-emersion, where an individual becomes immersed in her racial culture to the exclusion of other cultures; (d) internalization, when an individual maintains his or her own ethnic identity while interacting with people from other cultures; and (e) internalization, as in the commitment where the individual has internalized ethnic identity and works to advocate for social change (Cross, 1991).

In Cross's (1971, 1978) original model of Nigrescence, racial preference was believed (a) a "part of a Black person's personal identity and (b) to affect the person's mental health functioning" (Vandiver, Cross, Worrell, & Fhagen-Smith, 2002, p. 71). Cross's (1978) empirically validated racial identity scale (RIS) now encompasses two distinct components: personal identity and reference group orientation (Vandiver et al., 2002). Reference group orientations include social identities related to gender, sexual orientation, ability, or ethnicity. Worrell, Vandiver, Schaefer, Cross, and Fhagen-Smith (2006) found that the identity statuses indicated by RIS (2000) aligned with other Black identity markers when they studied students at a Historically Black College. Another scale of Black identity is the Multidimensional Inventory of Black Identity, which attempts to measure both universal properties of identity and the qualitative experience of Black people (Sellers, Smith, Shelton, Rowley, & Chavous, 1998). The Multidimensional Inventory of Black Identity measures three stable dimensions of the Minnesota Multiphasic Personality (centrality, ideology, and regard). As a White researcher working with Black children and their parents, it is important to remember that racial identity is complex and influenced by different environmental and personal factors; Ford and Harris (1997) posited that racial issues are likely to be "more salient for Blacks than Whites. For instance, White Americans are much less likely to experience the chronic stress and problems associated with racial identity because the color of their skin is not a barrier to success" (Ford & Harris, 1997, p. 105).

Stereotype threat. In situations where connecting a stereotype to one or more of a person's identities is relevant, stereotype threat may occur and determine the level of trust and belonging that an individual has that environment (Steele, 1997, 2010; Steele & Aronson, 1995). Stereotype threat can have a deleterious effect on performance (Larnell, Boston, & Bragelman, 2014). Steele and Aronson (1995) tested stereotype threat with Black college students. In each of four studies, the researchers tested the effect of negative stereotypes in situations where that stereotype was applicable. In one study, the researchers conducted a two-condition test with only Black participants. All participants took a nondiagnostic math test, but only the demographic information sheet for the experimental group asked participants to give their race. Participants in this cohort answered fewer questions and made more mistakes showing that stereotype threat significantly impacts academic performance (Steele & Aronson, 1995).

Neurological impact of stereotype threat. Krendl, Richeson, Kelley, and Heatherton's (2008) descriptions of the underlying neural conditions that aligned with the math stereotype threat for females showed stereotypes could make physiological changes, which would influence cognitive ability. Neuroscientists have found that stereotype threat can cause functional changes to the brain (Forbes & Leitner, 2014; Krendl et al., 2008). Stereotype threat has been found to significantly increase activity in the ventral anterior cingulate cortex (vACC) an area in the brain that helps process negative social information (Krendl et al., 2008). Negative feedback for those under stereotype threat conditions has been shown to activate the fusiform gyrus (Forbes & Leitner, 2014). Prioritization of the fusiform gyrus and the vACC to process negative social information, decreases neural activity associated with problem solving, subsequently impairing performance.

Identity as a protective factor. Having a strong sense of belonging in a math community is a key predictor of academic success (Phan, 2013; Tschannen-Moran, Bankole, Mitchell, & Moore, 2013). For this reason, students' coconstruction of various identities—

gender, race, and class—is relevant to math learning (Chavous et al., 2008). Other evidence has shown that maintaining racial identity in situations perceived as White may lead to fictive kinship relationships that undermine academic achievement. For some Black students, their peers' positive responses to academic achievement may undermine stereotype threat and support strong academic outcomes (Fordham & Ogbu, 1986). Even ambient cues in the classroom environment that remind learners of nonaffirming stereotypes can trigger stereotype threat and undermine learning opportunities (Cheryan, Plaut, Davies, & Steele, 2009; Steele & Aronson, 1995). Stereotype threat may cause some Black students to struggle with sense of belonging in an academic community (Brand, Glasson, & Green, 2006; Fordham, 1993; Larnell et al., 2014). Fordham (1993) wrote that academic success for some Black girls comes at the price of "voicelessness" (p. 3) or disassociation from stereotypes of "aggressive, loud, Black girls" (p. 3). However, a strong sense of racial identity may counteract stereotype threat on math test achievement (C. Davis, Aronson, & Salinas, 2006).

Often, a math learner's sense of self identity, and performance correlate (R. Anderson, 2007; Archer et al., 2015). For example, Schmader (2002) studied women who performed equally to men when no stereotype threat conditions were present. She found that on subsequent math tests those who listed gender as central to their self-definition were more vulnerable to stereotype threat than those who did not see gender as central to their identity. Schmader noticed that men, despite where they positioned gender in their self-conception, were not vulnerable to stereotype threat on math tests. This finding indicated that for females, strong gender identity may undermine performance when negative stereotype threats exist. Steele and Aronson (1995) wrote that stereotype threat is more likely to affect students who identify strongly as math learners than those who do not. Thus, a strong sense of social identity has not consistently provided protection against stereotype threat. C. Davis et al. (2006) argued that race and gender stereotypes threaten individual vulnerabilities in different ways. C. Davis et al. (2006) noted, “Both buffering and amplifying effects are possible outcomes of different racial identity statuses” (p. 403), an argument grounded in the work of Cross’s (1991) revised racial identity model of Nigrescence (see above for a description of the stages). C. Davis et al. (2006) found that students with the internalization status were less vulnerable to low-level stereotype threat when performing verbal GRE tasks than those with other statuses. However, in high-level stereotype threats, the internalization status did not seem to offer protection.

Family-School Collaboration

Yosso (2005) observed that many educators’ perceptions about minority students reflect deficit thinking. An educator with deficit thinking may have the idea that students are culturally deprived or deficient (Banks, 2015) or that they enter school without “the normative cultural knowledge and skills (Yosso, 2005, p. 85). School leaders may fault families for their children’s academic underperformances through the accusation that “parents neither value nor support their child’s education” (Yosso, 2005, p. 85). CRT has been used to reframe institutional perceptions of parent involvement to acknowledge and utilize the cultural wealth offered by members of the Black community (Banks, 2015; Watson & Bogotch, 2011). Black parents and family members place a high value on education and believe that college graduation has value (Immerwahr, 2000). Further, high parental expectations are often a factor in students’ academic success (Archer et al., 2015; Entwistle & Alexander, 1989; Leitch & Tangri, 1988). High achieving Black students often have the support of a parent or family member who teaches them to advocate for themselves in racialized educational institutions (McGee & Spencer, 2015). Parents and family members play a role in supporting their children’s academic achievement.

Many lower to middle socioeconomic class Black parents and family members do not trust that school personnel are invested in their children (Berry, 2008; Colbert, 1991; McNeal, 2014; Shriberg et al., 2012). Though caregivers typically want academic success for their children, they face barriers to developing effective collaborative relationships with teachers and other gatekeepers. Barriers to collaboration include parents' work schedules, socioeconomic differences between family members and teacher, and teacher job satisfaction (Leitch & Tangri, 1988). A greater understanding of how schools, especially public Montessori schools, could support collaboration between the parents of Black girls and teachers to build a foundation to support these students' academic self-efficacy.

Summary of Underlying Factors

Each of the underlying factors in this chapter was a potential driver of math underperformance for Black girls. Information about pedagogical studies that supported Black girls as math learning was limited; however, several beneficial strategies mentioned were incorporated in the Montessori pedagogy as used at PCM. One notable exception was the finding that a traditional pedagogy supports learning for Black children (see Love & Kruger, 2005; Lopata, et al., 2005). Other studies have shown teacher bias can influence children's ability to learn, and that teacher bias contributed to the quality of attention given to students (Hillman & Davenport, 1978; Scott-Jones & Clark, 1986), students' interests in math (Upadyaya & Eccles, 2014), and how teachers explain students' successes and failures (Espinoza et al., 2014). Any of these factors are likely to undermine math performance.

Social identity factors may also lead to math underperformance. Research studies showed that student sense of social identity correlates with student performance (R. Anderson, 2007; Archer et al., 2015), that stereotype threat can negatively affect student performance (Steele & Aronson, 1995), and that student attitudes about stereotypes can have a deleterious effect on cognitive functioning (Forbes & Leitner, 2014; Krendl et al., 2008). Finally, family-school collaboration has been found to affect Black students' academic performance. Parents' high expectations and advocacy supported academic achievement (Archer et al., 2015; Entwistle & Alexander, 1989; Leitch & Tangri, 1988; McGee & Spencer, 2015). Barriers to parent involvement include limited trust of teachers and lack of time (Leitch & Tangri, 1988), which might contribute to math underperformance.

The needs assessment described in the next chapter considers how these underlying factors influence the math learning of math learning at PCM. Data were collected based on interactions between teachers at PCM and students, as well as from the parent-child interactions of one fourth-grade classroom. The researcher also relied on the literature to learn more about how Montessori classrooms had supported learning for Black girls.

Chapter 2

Needs Assessment to Determine an Intervention

A literature review indicated pedagogical strategies, teacher bias, social identities in relation to math learning, transmission of cultural capital from parent to child, and collaboration between parent and teacher might be underlying factors that contribute to the problem of practice: the math underperformance of Black girls. The researcher conducted a needs assessment at PCM to determine which of these factors might be actionable in an intervention to address math underperformance. Data were collected using both quantitative and qualitative methods.

This chapter is organized into several sections that recount the process involved in conducting the needs assessment. Beginning with a contextualization of the problem of practice, subsequent sections (a) describe the selected underlying factors, (b) clarify the goals and objectives addressed by the needs assessment, (c) examine the needs assessment's methodology, and (d) summarize research findings. Factors investigated by the needs' assessment include teacher perception rooted in bias, identity constructs as they support students' sense of self as math scholars, institutional legitimization of Black parents' cultural capital, and collaboration between school and families.

Goals and Objectives

One original goal of this research study was to add to the literature about math achievement in public Montessori schools, especially for students of color. Currently, the research is limited and nonconclusive. Dohrmann et al. (2007) found standardized math test scores increased for students who attended a public Montessori school from age 3 to 11 compared to students who had attended a more traditional school during the same ages. Montessori students also had higher problem-solving ability than students in the control group (Lillard & Else-Quest, 2006), and they were stronger at social problem solving than the control group (Ansari & Winsler, 2014). However, Ansari and Winsler (2014) and Lopata et al. (2005) did not establish a significant advantage for Montessori compared to traditional math students. Lopata et al. found no social or emotional gains associated with Montessori. Not only were findings about Montessori and math nonconclusive, but few studies considered the experiences of Black children in Montessori contexts. This mixed-methods needs assessment was designed to identify actionable factors underlying the math underperformance of Black girls in Montessori contexts. To obtain a more suitable sample size and to avoid the ethical limitations posed by the student-researcher conducting research in her professional context, the dissertation research was conducted in a non-Montessori context, at CPS. Both schools shared a problem of math underperformance of Black girls; however, findings about the experiences of Black girls in a Montessori context were limited to the needs assessment. Research objectives that guided this study are outlined in the following sections.

Needs Assessment Research Objectives

1. What is the relationship at our school between teacher bias, the quality of teacher response, and student?
2. Which aspects of identity are most and least salient to girls studied in their understanding of themselves as math learners?
3. How do teacher and school climate help and hinder parent participation in school culture, and academic involvement with their children?
4. How do parents of Black girls feel that their expectations for their daughters' math learning is supported or not supported by teachers and staff at a public Montessori charter school?
5. How do pedagogical practices at the level of the school affect math achievement?

Context of Study

Sociopolitical and Historical Context

Broadly speaking, key sociopolitical and historical context factors that informed the needs assessment mini-study included racism and sexism. More specifically, the factors that might affect the target group as math learners included (a) historical inequity in how Black students have been privileged to access education; (b) social perceptions about girls and math learning; (c) the public Montessori movement (1970s) and permission for the creation of charter schools including PCM; (d) legal and extra-legal processes that establish and maintain high-poverty, hyper-segregated urban neighborhoods; (e) student families with low-socioeconomic status and social capital; and (e) a largely White, middle-class, female school faculty at PCM that does not reflect the diverse race, ethnicity, gender, or socioeconomic status of the students and families.

Greenhill North Neighborhood

Much of the information about the school neighborhood was gathered from private conversations and observation. Greenhill North, the neighborhood where PCM was situated, had transitioned from middle-class to poverty level with recent attempts to bring middle-class people back to the neighborhood through gentrification. In the 1940s, globalization and deindustrialization significantly decreased factory jobs in the area, which had emerged in the late 1800s as a mostly White, middle class suburb. By the 1960s, automobiles allowed those who had jobs in the city to live in the suburbs (Pietila, 2012). The ensuing exodus of workers led to disinvestment in neighborhoods and to abandoned buildings—approximately half of the buildings in the neighborhood were abandoned by the second half of the 20th century. Most of the traditional brick middle-class homes in the area were divided into apartments; many of these were demolished in the 1980s (Milner, 2013; Pietila, 2012; U.S. Census, 2010). Though neighborhood advocates, artists, and politicians have endeavored to beautify Greenhill North, the abandoned and boarded-up row houses are a reminder of entrenched poverty and neglect.

The mural-rich neighborhood is being gentrified as an arts district and the White, middle-class population is growing; however, most neighborhood residents are Black and live below the poverty level (U.S. Census, 2010). The current Greenhill North neighborhood association mission statement prioritizes both increasing the proportion of middle-class families in the neighborhood and ensuring affordable housing for long-term residents. However, it is unclear whether this mission statement will be enough to keep housing affordable for long-time residents. The neighborhood crime rate is higher than the national average with an especially high homicide rate. Anecdotally, several parents from the neighborhood have expressed concerns about neighborhood risks to their children, including frequent shootings like the one that occurred in 2016 in a neighborhood pocket park near the school where students sometimes play and that three students at PCM witnessed. Based on conversations, parents' concerns about children's safety sometimes lead to limits on the opportunities that children, especially girls, have to explore the neighborhood.

Resources for children in the neighborhood include a community afterschool care program for children. Housed in the same building as PCM, the community program charges 25 cents a week per neighborhood child for the after-school program where children have an opportunity to participate in activities, such as Spanish language lessons, STEM classes, African drumming, and a running club. The Greenhill North neighborhood has several pocket parks maintained by residents and a tool library. Soon, a weekly farmer's market will open on the edge of a neighborhood. Residents of the neighborhood are within walking distance of museums, libraries, theaters, a community college, and public transportation. A maker-space in the neighborhood has a pay-what-you-can policy for its family-oriented classes in sewing, electronics, and other technologies. They also offer after-school and summer classes for students.

Another neighborhood resource is the longevity of many families in the neighborhood. Several parents of PCM students also grew up in Greenhill North; often, several generations share one residence or at least live close enough to interact on a regular basis (Jeter, 2016).

Schools in Greenhill North

Greenhill North is home to two schools: a public, middle-high school and a PCM, a prekindergarten through eighth grade public, charter Montessori school. However, neighborhood children are zoned to go to a traditional public elementary school in an adjacent neighborhood, Charles H. Houston Elementary (pseudonym). The population at Charles H. Houston reflects neighborhood hyper-segregation that is predicated on more than a century of Jim Crow era sanctions, zoning laws, and redlining with a student body that is 88% Black, 1% White, 7% Hispanic, and 3% Asian. In its capacity as a public charter school where enrollment is determined through a lottery system, PCM has a more diverse student body, drawn from every zip code in the city. The ability to draw from different neighborhoods makes it possible for PCM to have an approximately equal number of Black and White students (and a small number of Latino or Asian students), as well as a socioeconomically diverse student body. A recently instituted Geographic Attendance Area waiver permits PCM to take 10% of its student population from the neighborhood. This waiver is controversial within the Greenhill North neighborhood, which historically has not been large enough to support two elementary schools. In private communication, several community members expressed opposition to PCM taking students who are zoned for Charles H. Houston. Others said that attendance at PCM should be prioritized for Greenhill North children.

At first glance, PCM is a model of racial and socioeconomic integration. However, performance data show that Black children consistently underperform. Most Black kindergarten students entering PCM in the fall of 2015 demonstrated readiness to learn mathematics as determined by scores on a local kindergarten assessment measure. However, only 25% of the

2015-2016 class of Black fourth-grade girls at PCM has math scores that put them on track for college as measured by the NWEA (2016). Without longitudinal test data tracking the math progress of this group of girls—many of whom joined the school in the third or fourth-grade—no reasonable connection between the kindergarten and fourth-grade scores can be made. It is not possible to state with confidence that the Black girls' academic achievement decreased while at PCM. However, current data showing that only 25% of PCM's Black girls are on track for college (NWEA scores of proficient or advanced) are an indication of the level of math underperformance addressed here.

The school's predominantly White, middle-class administrative and teaching staff does not reflect students' racial and socioeconomic backgrounds. To address concerns about this gap as a probable source of educational inequities, the school had an equity audit involving feedback from staff, students, and school families, and is engaged in an ongoing professional development that addresses racism, including within the context of the school. The administration has increased the diversity of its teaching and administrative staff. At the request of current teachers, the school attempted to eliminate within-school segregation by balancing the gender, race, and ethnicity of the student populations across classrooms. Staff members have used Bank's (2015) dimensions of multicultural education (see Figure 1) to increase the cultural responsiveness of the curriculum and other aspects of the school climate and experience. Still, observations show that the school staff does not reflect the demographics of the student population and that academic underperformance of Black children persists.

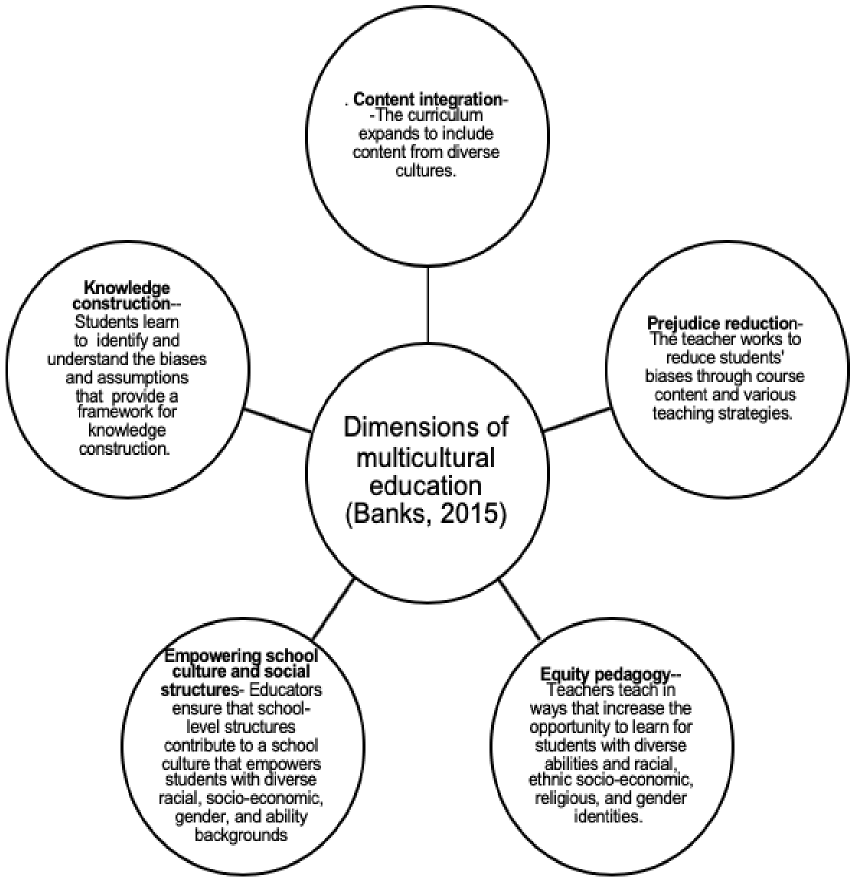

Figure 1. The dimensions of multicultural education.

A needs assessment conducted to identify underlying factors for math underperformance in the public Montessori context included a focus group to gather information about family impressions of and experiences with school math learning related to their daughters (see Jeter, 2016). Two-thirds of the participating family members live in Greenhill North. At the focus group with three Black family members—two mothers and one grandmother—from diverse socioeconomic status and educational backgrounds, parent-family collaboration emerged as an actionable factor (see Jeter, 2016).

Parents shared a range of race and gender related perspectives to explain Black girls' aptitude for and interest in math (see Appendix A). Some attributed lower math scores and interest levels to the way that girls were socialized; others believed that girls were innately worse at math than boys (see Jeter, 2016). Focus group participants mentioned Black students are more likely than White students to go to substandard schools, and Black families often have less access than White, middle-class families to programs and resources that might support their children's math learning (Jeter, 2016). Focus group members frequently answered questions about the effects of race on education by sharing information about the influence of poverty on education. The literature provides a rationale for this conflation of Blackness and poverty: despite poverty's existence in all demographic subgroups, racist institutional policies and customs over generations have resulted in a higher percentage of Black families compared to White families living in poverty (Knaus, 2009; Ladson-Billings & Tate, 2016; Milner, 2013). The conflation of race and class also reflects historical inequities in the way that resources have been allocated to educate Black compared to White schoolchildren (Parsons & Turner, 2014; Pellegrino et al., 2013; Roza et al., 2004). Ladson-Billings (2006) described this historical variance in per-pupil expenditure as an educational debt to Black children. Following Ladson-Billings's (2006) suggestion, gaps in achievement do not reflect the deficiency of Black children in a meritocracy. Instead, achievement gaps testify to the social and structural racism that has perpetuated educational inequity. Unpaid educational debts are lost or stolen opportunities.

Purpose of the Needs Assessment

The purpose of the needs' assessment was to explore underlying factors that might contribute to math underperformance of Black girls. Through this exploration of both phenomena in the classroom and the literature, the researcher sought an actionable intervention to address the problem.

Method for the Needs Assessment

Needs assessment research design. Components of the research design, participants, and methodology are discussed below. The procedure, including the outline of steps and the timeline, is described with attention to data collection methods and data analysis. A discussion of the findings and an elaboration of the description of context based on the empirical study follow.

Context of participants. The context of the needs' assessment is a public charter Montessori school in a Mid-Atlantic city with approximately 250 students ranging from prekindergarten to the eighth grade. The school draws 10% of its students from the Greenhill North neighborhood, a gentrifying but still high poverty area. Other students were chosen through a lottery process resulting in a diverse student body drawn from all zip codes in the city. The needs assessment was conducted with one of the four upper-elementary classrooms (fourth through sixth grade) at PCM. The primary classroom assessed was led by a White female Montessori trained guide and a Black female assistant teacher who was a Montessori guide at the school. The 26 students in the class were evenly divided by gender. There were 16 Black, eight White, and two Asian children. The girls in the fourth-grade cohort were the focus of this needs' assessment. All students were given DAM survey and the Math Attitude test. Only the data from 11 students who submitted IRB forms were used. The focus group comprised two mothers and one grandmother. Five teachers were observed for the implicit bias component of the needs' assessment.

Students' academic achievement. This needs assessment examined potential underlying factors of math underperformance, as indicated by NWEA scores, and informally collected school-wide data from the 2014 to 2015 Kaufman (2014) Teacher's Educational Assessment III (KTEA III; see Table 1). Students took three different versions of the skill- based math section over the course of the school year (problem-solving and applications are not tested). The data showed 13% of Black third-grade girls performing on grade level. Other third-grade students, Black boys, White boys, and White girls had 57%, 60%, and 87% on grade level, respectively. All fourth-grade students performing below grade level on the middle of the year KTEA III also qualified for free and reduced meals; thus, including data aggregated to show socioeconomic status might have contributed valuable information.

At the beginning of the year, only one fourth-grade girl was testing on grade level, as indicated by the KTEA III. The end of year KTEA III data showed all but two of the girls were on or above grade level. The two girls still below grade level demonstrated either 9 months or 3.5 years of progress. At the beginning of the year, two of the five fourth-grade boys were on grade level. At the end of the year, all fourth-grade boys were on grade level related to math skills, as measured by the KTEA III. On another measure, the NWEA (2016), only 25% of Black fourth-grade girls in the class scored proficient or advanced. This compares to 100% of White fourth-graders (male and female), and 33% of Black fourth-grade boys who scored proficient or higher. Aligned to Common Core standards, the NWEA (2016) claimed to give fair and reliable assessments across populations. Unlike the KTEA III that measured skills in isolation (see Table 1), the NWEA required students to use skills to solve problems, thereby more accurately measuring the math ability needed to succeed in higher education. These data showed greater disparity between races than between genders

Table 1

Third-Grade KTEA III Scores

	Black girls	White girls	Black boys	White boys
Grade level +	2	7	5	10
Below grade level	6	0	2	0
N	8	7	7	10
Percentage	13	86	57	60

Families. Of the five family members who volunteered to attend the focus group, three participated. Each had a daughter or granddaughter in the fourth through sixth-grade class. Each participant self-identified as Black. All participants mentioned that they have participated in learning activities at home. Family members also volunteered at school, for example, by making t-shirts for the school step team or by chaperoning field trips. Epstein's (1988) framework of parent involvement offers the following broad categories of involvement: (a) volunteering, (b) at-home learning, (c) decision-making, and (d) community engagement. Using this framework as a guide, each participating family members engaged at least in the first four categories. The three girls represented here are Marie (Nora's granddaughter), Sky (Angela's daughter), and Destiny (Sarah's daughter). All names are pseudonyms chosen when possible by the representative child or family member.

Nora. Nora represented her granddaughter, Marie. The needs assessment occurred during Marie's first year at the school, and Nora attended every student conference or parent meeting. A woman in her 60s, Nora raised Maria and her younger brother Malik in the Greenhill North neighborhood. Nora graduated from high school in the city. She attended a Historic Black University, also in the city, for one semester, but dropped out to help her family. She now works for the government, helping people with disabilities to get their checks. Nora has supported her grandchildren's education on many of the levels represented by Epstein's (1988) framework. She made t-shirts for a recent step show and bakes cookies for bake sales. She supports her grandchildren's education by modeling behaviors, incorporating academics into everyday activities, and by assigning work based on school standards. Nora does not like to read, but after work each night, she reads to set a good example for her granddaughter who struggles with reading fluency. Nora does not spank her grandchildren, and they know that their grandmother has high expectations.

Nora strives to assimilate academic lessons into everyday experiences. At family movie night, the children had to practice arithmetic to "buy" a ticket, popcorn, or other amenities. When cooking with her grandchildren, Nora made them aware of the math involved. Nora has also engaged with the community. She, Marie, and Malik attend rallies and other actions, including visiting the state capitol to advocate for more money for public schools. She participates in other civic organizations including one focused on stopping gun violence in the city.

Angela. This needs assessment occurred during Sky's second year at PCM. Her mother, Angela, attended the focus group. Their family lives in Greenhill North where they own the row house that Sky's father grew up in. Angela painted the house a warm pumpkin color to make it stand out, because she likes different things. Both Angela and her husband have been in the neighborhood for a long time; they attended middle school in the same building that today accommodates PCM. Angela, her husband, and Sky share a home with Sky's seven siblings, including two who attend PCM, and a brother who attends a local college. Other than walking to and from school, Angela does not allow the girls to do errands, take out the trash, or play outside without supervision. Angela and her husband work in transportation, and they are, in Angela's words, the "working poor." Their family attends a Christian church most weeks, and religion is central to their family life. Angela participates in Sky's education at the second level on Epstein's (1988) framework by communicating with the teacher by email and attending conferences. At the fourth level (at-home learning), Angela ensures her children do educational activities at home. When Sky was struggling with reading, Angela worked with her each evening. Angela believed she made a difference. Before Sky went to school, she and her mother did language and math activities at home. However, Angela had to start working when Sky was a toddler and resents having had to send her daughter to daycare. Angela notices that, unlike her other children whom she stayed home with, Sky struggles more with academic work. She feels that she missed an opportunity to give her daughter a strong academic start.

Sarah. Destiny's mother, Sarah, attended the focus group. Destiny and her younger sister had attended PCM for 2 years at the time of the needs' assessment. Sarah also has a newborn child. Destiny is biracial (Black mother and White father). The family lives on the Southwestern side of the city where Sarah works as the principal of a Christian school. The father is a youth minister. Both parents are college graduates, and Sarah is attending graduate school. Using Epstein's (1988) framework, Sarah engages at the second level (communication), third (volunteering), and fourth (at home learning). Sarah communicates with the school through email, and she attends conferences. Sarah has chaperoned field trips including the class camping trip. Sarah tries to engage her daughters in interesting learning experiences, including programs at a nature center and summer camps.

Teachers. Five PCM teachers volunteered to be observed for this assessment. Three teach at the upper elementary level (fourth grade through sixth grade), one teaches in the lower elementary (first through third grade) and the last teaches middle school. The teachers observed were White women, each with at least seven years of teaching experience. Of the five teachers, three were in their first or second year at the school. Two had been at the school for 5 or 6 years. None of the teachers are native to the city. Observations of one teacher were not recorded because the interactions between students and teacher were minimal, and the class was not demographically diverse enough to collect the data needed.

Methods and Instrumentation

Measures

Dependent variables tested included teacher bias, parent perception of the school, and student sense of identity related to math. Teacher bias was measured through observation and through an implicit bias test. Parent perception was measured through a focus group. Student identity constructs were measured with a Draw-A-Mathematician test (modified from a Draw-A-Scientist test). The measure for each variable is described in more depth.

Teacher bias. The Implicit Association Test (T. Greenwald, Banaji, & Nosek, 1998) and observations of teacher-student interactions were used to learn more about the relationship between teachers' racial biases and how teachers allocate attention to students. The Implicit Association Test was designed to measure automatic associations between concepts (T. Greenwald et al., 1998, p. 1023). In the computer based IAT used here, participants paired words with either a positive or negative valence with pictures of White or Black people. The speed with which participants match Black compared to White people to concept words measures the magnitude and direction of the participant's racial bias. A. G. Greenwald and Farnham (2000) found that the association-strength measure was stable and not likely to be influenced by participant's familiarity with testing items or the way that items were arranged on the computer screen. The IAT showed a weak test-retest reliability over twenty studies ranging from .25 to .69 with a mean reliability of .50. Others have reported that the test is not sufficiently reliable for new users (Rezaei, 2011).

In a meta-analysis of three research studies using the IAT, A. G. Greenwald and Farnham (2000) found construct validity in three forms: known groups' validity, predictive validity, and discriminative validity. In a meta-analysis of 122 research studies, predictive validity grew stronger when IAT was correlated with self-reporting (A. G. Greenwald, Poehlman, Uhlmann, & Banaji, 2009). Oswald, Mitchell, Blanton, Jaccard, and Tetlock (2015) found that the IAT's ability to predict behavior was weak, which contradicted A. G. Greenwald, Banaji, and Nosek's (2015) interpretation of findings for the same meta-analysis. Differences in research interpretations can be attributed to the researchers' respective data analysis methods. For example, whereas A. G. Greenwald et al. (2015) averaged the effect sizes found across the meta-analysis, Oswald et al. (2015) "used analytic methods that allowed (us) to model the underlying statistical dependencies. This improved the estimation of variation across (random) effects and yielded correct standard errors in mixed-effects meta-analysis modeling" (p. 564). Consequently, Oswald et al. (2015) found a small mean effect sizes between and within control and treatment populations. Oswald et al. questioned the construct validity of the IAT, which they claimed makes hypotheses based on assumptions that have not been rigorously tested and are still debatable. Oswald et al. suggested that future IAT research address external validity. Blanton et al. (2009) and others argued that the IAT may measure constructs other than implicit bias, which undermined the construct validity of the psychometric measure. Despite some controversy about the reliability and validity of this measure, the IAT could be useful as an educational measure for helping educators think about their implicit biases.

Identity constructs. Students were asked to complete a survey about their attitudes toward math. Next, they took a modified version of the Draw-A-Scientist test (DAST; Chambers, 1983). The DAST, influenced by Mead and Metraux's (1957) study of high school students' images of scientists, is a projective, open-ended test that attempts to measure participants' stereotypical perceptions of scientists. Children's drawings of scientists are given one point for each of seven indicators encountered: lab coat, eyeglasses, facial hair, symbols of research, symbols of knowledge, products of science (technology) and relevant captions (Chambers, 1983). Ethnicity and gender were not original indicators. Chambers (1983) referred to differences between participants from different ethnicities, socioeconomic status, and gender groups. For example, he looked at how students from different countries visualized scientists. However, he did not consider social identity indicators in the drawings of scientists. Sumrall (1995) modified DAST to observe the relationship between race, gender, and the stereotypical indicators. Several researchers have adapted the DAST to learn more about stereotypical perceptions of different vocations including computer scientists, engineers, and archaeologists (Capobianco, Diefes-dux, Mena, & Weller, 2011; Martin, 2003; Renoe, 2003). Here, the DAST was adapted to consider students' perceptions of mathematicians. DAST has a reliability coefficient reported to be 0.902 and 0.806. Finson (2001) found the DAST checklist was a valid measure across racial and socioeconomic status groups.

Parent teacher interactions. A focus group was conducted. Parents responded to prompts about their daughters' educational needs and experiences.

Pedagogical practices. A review of literature provided insight into how the Montessori Method aligns with pedagogical practices known to support math achievement of Black girls.

Parent and teacher collaboration. The themes gathered from the focus group and the City School Climate Survey (2014-2015) showed that parents were happy with PCM in many categories. The weakest climate scores were given by parents and family members who had experienced low-access to student activities and who would like a more robust school-community connection. More optimistic about the family-school partnership, but still wanted more access to participation in their children's education. The focus group conversation was transcribed, and then coded with themes that included pedagogy, gender bias, family-school relationships, and racial bias.

Procedure

Timeline. In January, 2016, after getting permission to conduct a needs assessment from the head of school at PCM, parents were informed of the measures involving student or parent/family member participation. Institutional Review Board (IRB) permission was collected from those students and family members who chose to participate in the needs' assessment. All students were given the math attitude test. All students also took the Draw-A-Mathematician test. Data were collected only for those students who had turned in a completed IRB. During winter, and early spring, the investigator collected IRB permission from teachers before observing their interactions with students. Teachers were also asked to independently take an Implicit Attitude Test and to report the score to the researcher. Parents of fourth-grade girls were invited to a focus group, which was held in April, 2016. In April and May, data were analyzed and conclusions drawn.

Data collection methods. Though some findings from test data and the literature are shared in the initial summary of results, this section focused on the measures used to collect data about teacher bias, math identity, and parent-teacher interactions.

Teacher bias. Teachers were invited to participate in a study by e-mail. Five agreed to participate. The study consisted of four 15-min observations and an IAT. Teacher bias was measured by how frequently the teacher allocated attentional resources to students in different demographic groups. Attentional resources were defined as (a) teachers allowing students to speak on-topic, (b) teachers allowing students to speak off-topic, and (c) teachers eliciting further information from a student. Five teachers were observed for four 15-min sessions. However, several observations did not yield teacher-student interactions. In Montessori classrooms, learning only occurred through teacher-student interactions. One teacher was not working with a racially diverse group of children. Only four teacher's data for two 15-min sessions was used.

Implicit Attitude Test (IAT). Teachers were asked to take the race version of the IAT test. The underlying hypothesis was that teacher bias would determine the number and quality of interactions between student and teacher and subsequently influence educational opportunity. Only two teachers shared results of the IAT. The remaining teachers did not. It is not clear if teachers felt uncomfortable sharing the results, or if they simply forgot to take the test. Of the teachers who shared their IAT results, one teacher was biased toward Black people, the other toward White. The teacher whom the test scored as biased toward White people said that the test confronted her self-understanding. She was disappointed in the score and said that the information was useful to her as a teacher. There was no observed correlation between the test results and how attentional resources were shared. In the future, it would be useful to include IAT tests that look at gender, specifically at gender related to math and science. The small sample size limited the conclusions that might be drawn from these data.

Observation. The observer looked at whether White female teachers' allocations of attentional resources had a gender or racial bias. The observer recorded three types of teacher-student interactions. Types of teacher-student interactions that were tallied (a) teacher allows the student to speak on topic, (b) teacher allows the student to speak off-topic, and (c) teacher elicits further information from the student. The researcher recorded each interaction by making a mark in the section of the observational record that aligned with the student's gender and race.

Each teacher was observed for two 15-min sessions. Teachers did not know what aspect of their teaching was being observed. In cases where there was no teacher student interaction (e.g., students were writing at a desk), teachers were observed, but no data were collected. In several observations, the lesson observed was not diverse enough to be used for observational purposes. Observational data were converted into ratios that compared the number of times a student in a specific racial and gendered demographic was given attention and the number of students in that demographic. Data for all classes were combined to find an average teacher-student interaction rate for each group.

Student identity constructs. All students were required to take a math attitude test and a modified version of the DAST. Those students who wished to participate in the research study signed forms from Johns Hopkins's IRB forms.

Math attitude test. Students took a Likert test about their attitudes toward math. The test was distributed during class time and all students took it at the same time. The eleven students who had turned in IRBs took the test through a Qualtrics link.

Draw-A-Mathematician. Each student was instructed to draw a mathematician. On another page, the student wrote several sentences describing characteristics of the mathematician. The student also wrote about how he or she was like the mathematician. This researcher measured students' sense that a mathematician could have their identity constructs by giving one point for each characteristic included in the drawing or description that matched an identity construct of the student.

Parent-teacher collaboration. Fourth-grade parents and family members were invited to a focus group. They filled out demographic forms and then participated in a conversation about their daughters and math. Five parents indicated that they would come, but only three showed up.

Focus group. Parents met in the community room with the doors closed for privacy. Pizza was served. All participants sat around a circular table. A cell phone was used as a recording device. Participants passed the phone around the table to whomever was speaking. Children came into the room a couple of times and one participant's cell phone rang. Other than that, there were no disruptions. The facilitator asked one question at a time (See questions directly below). After each question, participants took turns answering.

Assessment Focus Group Questions

1. What do you wish had been different about math when you were in school? What did you enjoy?
2. How do you use the math that you learned in school today?
3. In a perfect world. What does math class look like for your daughter?
4. Now, let's talk about your daughter and math. How does your daughter feel about math? Does she see herself as a math learner?
5. Think about careers. What would you like for your daughter to do when she grows up?
6. Let me ask you, how do you see that (career aspiration) meshing with math...
7. From your experience, how do you think boys and girls learn differently?
8. Historically, in our city and in our country, the playing field has not been equal for all races and genders. This inequity continues to affect many aspects of our lives from how we are treated in traffic to our access to health care. How do racism and sexism affect learning? How do they affect learning for your daughter?
9. What could a teacher do to help you feel more connected to what is happening at school?
10. What is one thing that would help your daughter to see herself as a math scholar?

After the session, the recording from the focus group was transcribed. Themes were sorted into categories that supported the constructs studied: math identity, parent interactions in schools, pedagogy, and bias. Next, subcodes were determined, and the frequency of each was recorded. Next the text was divided into themes related to the operational concepts approached in this study. The frequency with which different thematic topics were mentioned was analyzed using SPSS data (see Table 2)

Data Analysis

Key Findings

Here are key findings for each construct addressed.

Teacher bias. Only two teachers in an already small sample reported their Implicit Bias Test scores. Any information discovered about teacher bias and the number of times teachers interacted with students is inconclusive. Table 2 shows data from six (*N*) teacher observations. Though not correlated to teachers' implicit bias, they do indicate patterns in how race and gender determine the attention that a student might receive from a teacher. Data for three teachers' interactions with students were collected. Each teacher was observed twice. The observer recorded teacher student interactions in five classes for two 15-min sessions each. The observer recorded the ratio of participation for each subgroup across observations in three categories: (a) The teacher allowed an on-topic comment, (b) the teacher allowed an off-topic comment, and (c) the teacher elicited further information from the student. Teachers favored White boys by allowing them to make more on-topic comments and by eliciting information more frequently from them than from other student groups. Boys (White and Black) made more off-topic comments than girls but White girls made off topic comments slightly more frequently than Black girls who made none during these observations. The teacher elicited information 1.69 times for each White male in comparison to 0.44 times per Black male, 0.6 times per Black female, and 0.92 times per White female. Black females did not speak off topic in any of the six lessons observed. Though Black girls and boys each interacted once per teacher, the girls' interactions were more likely to be related to the lesson. When all categories are considered, the data show that White males interact with teachers twice as frequently as White females, and approximately three times as frequently as Black boys and girls. The sample size here is small but the pattern is consistent within that small sample.

Table 2

Focus Group Topic Frequency

Theme	*N*	Minimum mentions*	Maximum mentions*	*M*	*SD*
Parent role	3	5	8	6	1.73
Pedagogy	3	1	6	4	1.73
Gender	3	2	5	3	1.73
Race	3	1	4	2	1.73
Identity	3	0	4	2	2.00

Note. * Minimum or maximum by an individual participant.

Observations for this small sample showed a bias toward White boys and against Black girls. Black boys were given more attention from teachers than Black girls; however, much of the attention was disciplinary. Though the magnitude of this bias varied from teacher to teacher, the pattern of implicit bias was consistent across classrooms (Jeter, 2016).

Student identity. Students had positive attitudes about math. The math attitude test indicated that students feel positive about themselves as math learners. Overall, seven of the eleven children disagreed that math is their worst subject. Three answered the question as neutral. One said that math was her least favorite subject. On the Draw-A-Mathematician Test, almost every girl visualized a mathematician who shared identity constructs with herself. The chart showed each participant's race and gender, as well as how many self-identifying constructs the participant drew (see Appendix G). Included in most cases was a description of the mathematician. Some students also wrote about how they were like or not like a mathematician. Others described the path toward becoming a mathematician as one of work and persistence rather than innate identity. There is also evidence that students connect math learning to larger issues. One student said, "The world is made of math." Another student feels "magical" when doing order of operations problems. If math makes a student feel as if she has magical powers, this is an indication that she is an empowered math learner. These data showed student attitudes after a semester in a classroom where the teacher explicitly worked to support students' social identities as math learners. Collecting the same data earlier in the year might have yielded a different result.

Key theme of the focus group discussion. Themes that emerged from the focus group were parent role, pedagogy, gender identity, and racial identity (see Appendix C). Subcodes related to parent and family member involvement included low self-efficacy related to understanding school math and low- helping children's academic achievement. Even where caregivers visited the school and were aware of what work students were doing in the classroom, they were not sure of how to advocate for their child's academic success. Additionally, many caregivers lacked the time to be as involved as they wanted to be. Subcodes related to pedagogy included concerns that "school math is different than my math." Parents appreciated the social learning, peer teaching, and 3-year instructional cycles found at Montessori. They appreciated the real-life math applications and the emphasis on hands on work. Parents wanted more learning connected to "real-life," having greater emphasis on children learning core math skills, and finding multiple ways to solve problems. Gender identity related themes included giving girls more exposure to Black female STEM role models. Some parents and caregivers thought that boys are more independent learners and "more wired to be better at math." Others believed that girls' beliefs about themselves as math learners is related to cultural and social messages generated by families, schools, and society. Race identity related themes included the observation that teachers underestimate or have low expectations for Black learners. Parents and caregivers also observed that Black children in city schools are more likely to be given fewer advanced academic options and more likely to be tracked into service careers than children in schools or districts with a higher proportion of White children. One parent mentioned that the counter-narrative needed to succeed can be stressful for Black children (see Appendix B).

One limitation of this study was that the race of the focus group facilitator (White) might have made parents feel less comfortable about addressing racial issues, especially those related to the school and classroom. Additionally, the parents might not have wanted to express their feelings about their daughters' experiences at school in front of their child's teacher. In the future, participants should have the opportunity to contribute anonymous suggestions.

Pedagogy. The empirical literature about Montessori math was limited, and studies have not conclusively determined causation between the Montessori method and math outcomes for learners, especially Black females (Ansari & Winsler, 2014; Dohrmann et al., 2007; Lillard & Else-Quest, 2006; Lopata et al., 2005). However, other literature gives information about strategies that align with academic achievement for African American students.

In many cases, the Montessori math program incorporates strategies found to support learning for Black girls. These include giving learners and teachers formative feedback, using peer tutors, giving parents specific feedback on children's math performances, balancing open-ended explicit instruction with problem solving (Baker et al., 2002). Other strategies are used by some teachers but not others. R. Gutiérrez (2000) advocated for curriculum that is culturally relevant, rigorous, and innovative and one where teachers are responsive to their students. There is no school-wide standard to measure whether teachers do this. Finally, Ladson-Billings (1995) contradicted a deficit-oriented assumption that race is not a salient part of education. She posited that culturally competent teachers must be able to foster student academic achievement, support cultural competence, and encourage the development of critical consciousness. The way that individual teachers at PCM contextualize learning in critical race consciousness varies and was not measured. Ladson-Billings (1995) wrote about a need for culturally competent teachers able to foster student academic achievement, support cultural competence, and encourage the development of critical consciousness. She was critical of teaching practices that expose Black children to new experiences without holding them accountable for learning skills that will be tested on high-stakes tests (Ladson-Billings, 1995).

Research Question Responses

Revisiting the research questions after the needs' assessment showed actionable constructs. After reviewing and responding to each needs' assessment research question, the choice of constructs are addressed in the intervention and defended.

Question 1

The first question asked in the needs assessment explored the relationship at our school between teacher bias, the quality of teacher response, and the student. As described above, there was a pattern in how teachers distributed attention (Jeter, 2016). However, not only is the sample size too small to attribute significance to the patterns observed, there are also likely to be internal validity concerns, including selection-maturation interactions, which might arise from observing different aged classes, subjects, and times of the day. Only two teachers completed the IAT. Differing biases did not show a positive correlation to the way that teachers distributed attention. Once again, the sample size was too small to draw any meaningful conclusions from these data.

Table 3

Teacher-Student Interactions

Group	Behavior	*N*	Range	Min	Max	*M*	*SD*
Black girls	On task	6	2.0	0	2.0	0.542	0.813
	Off task		0.0		0.0	0.000	0.000
	Tt elicits		2.0		2.0	0.600	0.790
White girls	On task	6	2.7	0	2.7	0.110	1.009
	Off task		0.7		0.5	0.270	1.009
	Tt elicit		1.3		0.9	0.499	0.200
Black boys	On task	6	0.5	0	0.5	0.105	0.200
	Off task		3.0		3.0	0.500	1.225
	Tt elicit		1.5		1.5	0.437	0.600
White boys	On task	6	4.0	0	4.0	1.127	1.533
	Off task		3.0		3.0	0.500	1.225
	Tt elicit		5.0		5.0	1.693	0.710

Question 2

The second question addressed which aspects of identity were most and least salient to the way that girls understood themselves as math learners. Most girls drew mathematicians who reflected their own identity constructs (see Appendix G). One Black girl drew a noncolor specific female mathematician: “He can be any race”! (see Jeter, 2016, p. 20). Another Black girl drew a female mathematician without specifying race. The two Asian female participants drew Asian female mathematician. Five out of seven Black female participants who submitted IRBs drew Black female mathematicians. The one White female participant drew a White female mathematician. The researcher could find no positive correlation between girls’ drawings and their academic achievement. It is difficult to know whether there might be other positive connections. Even where girls did not demonstrate strong academic outcomes, is it possible that a strong self-concept as a mathematician might have a mediating effect on girls’ attitudes about math learning that eventually result in higher math competence?

Question 3

The third needs assessment research question asked how teacher and school climate would help and hinder parent participation in school culture and academic involvement with their children. Parents at the focus group said that they appreciate information sent home by the teacher and that they felt the teachers did a good job with communicating both positive events, and concerns. They believed across the school, teachers were concerned and care about their children (Jeter, 2016). The parents at the focus group compared this school favorably to other schools where their children have attended. The parents may have withheld negative comments or criticisms based on the teacher's presence. The participants' willingness to participate may be an indication that they think more favorably about the school than other parents.

Question 4

Needs assessment research question number four addressed how parental expectations about their daughters' math learning are supported or not supported by teachers and staff at PCM. Parents mentioned that the teacher sends home informative, weekly letters so they know what is happening in class. However, parents are not sure about how to support their children's success as math learners at PCM (Jeter, 2016). Anecdotally, some parents have expressed frustration about how to help children with "new math," "Montessori math," and "school math." At a focus group, students spoke about the general tendency for White teachers to have low expectations for girls and for Black students. Parents, both in private conversation and at the focus group (Jeter, 2016) described strategies used at home to support their daughters as math learners. Parents described the ways that they connect math to cooking, shopping, and predicting how much gas will be needed on a trip. Some parents used workbooks, online math tutorials, and computer games to support their children as math learners. One participant created math experiences for her children. For example, one evening, she made her living room into a movie theater where children had to purchase tickets, popcorn, and other aspects of the movie-goer experience. Despite using a toolbox of strategies to incorporate math learning at home, parents demonstrated low-self efficacy with supporting their daughters as math learners. Several parents mentioned that homework would help them to connect with math instruction at school.

Question 5

Finally, the needs assessment sought to understand how pedagogical practices as the level of the school support math learning for this cohort of Black girls. As mentioned in the last chapter, the extant research literature offers no conclusive evidence that Montessori supports math learning. However, the Montessori method does make use of strategies that have been found to support math learning for Black girls. Socially constructed learning strategies such as peer tutoring, collaborative learning, formative feedback, and student-centered learning are especially salient elements of the Montessori method (Montessori, 1917). The occurrence of other pedagogical strategies shown to support math learning vary. These include a rigorous curriculum, culturally responsive teaching (Gay, 2002; R. Gutiérrez, 2000), specifically from a critical race perspective (Ladson-Billings, 1995).

Findings and Discussion

Though low sample sizes limited the validity of findings from this needs' assessment, findings did indicate strategies that might inform an intervention for the problem of math underperformance of Black girls in this setting. The needs assessment indicated that teachers should allocate more attentional resources to White boys compared to students from other demographic groups. Though the limited findings might not be generalizable across the school, these were reliable enough with a small sample to indicate that implicit bias that favored White males existed at PCM. Implicit bias added to the problem of math underperformance for Black girls. Although implicit bias is currently being addressed with all teachers at professional development meetings, which may be a reasonable focus of an intervention contextualized at PCM.

Pedagogy is another area likely to influence math performance. Though somewhat critical of the limited opportunities for family-school collaboration related to academics, focus group parents praised the hands-on, collaborative learning at PCM. This input from families made an overreaching pedagogical shift seem less than desirable (Jeter, 2016) had the intervention been conducted at PCM as originally planned.

Early on, collaborative partnerships seemed actionable. Informal communications between parents and the teacher support findings from the focus group that parents and family members (a) have low self-efficacy with supporting their daughters as math learners, and (b) would like stronger home-school connections related to curricular content. Parents have mentioned that homework would help them stay more connected to what their daughters are learning. On an institutional level, the school wishes to strengthen its school-family-community partnerships. Focus group findings support an exploratory intervention to learn more about how school-family partnerships support students' academic achievement.

The Draw A Mathematician test given to students during the needs' assessment indicated that most students have strong self-concepts of themselves as math learners. However, the assessment was given mid-way through the year after teacher had explicitly worked with students on developing their self-concepts as math learners. Though the needs' assessment had no conclusive information about the connection between social identities and math learning at PCM, there is substantial literature that does provide support for the idea that student sense of self affects learning (Aronson et al., 1999; Beilock, Rydell, & McConnell, 2007; Steele & Aronson, 1995). Needs assessment findings and anecdotal information from the school context led to a decision to focus the intervention on several constructs: parent self-efficacy with supporting their daughters as math learners, family-school engagement, and student self-concept as a math learner. In the third chapter, a review of the research literature on family-school interventions is used to determine a course of action for the research intervention at CPS.

Chapter 3

Intervention Literature Review

Chapter 3 includes a review of the literature and needs assessment findings used to determine this research intervention. Constructs used in the intervention—specifically family-school collaboration, and parent self-efficacy with supporting their daughters as math learners—are operationalized. Next, the researcher provides a rationale for the intervention. Finally, the intervention's frameworks are described, and literature related to the intervention is reviewed. Chapter 3 also connects the needs assessment and research site, as mentioned earlier.

Intervention Constructs

The needs assessment (Jeter, 2016) was used to identify the constructs that were addressed by the intervention: family-school collaboration, and parent self-efficacy with supporting their daughters as math learners. Black girls' math achievement and sense of themselves as math learners were desired outcomes. Other constructs examined in the needs assessment might contribute to the problem of math underperformance but were found less actionable within this context.

Parent-School Engagement

J. L. Epstein (personal communication, August 3, 2016) cautioned educators against relying on the idea that parent involvement is limited to visible, in-school parent presence. Such a model is normed to a White, middle-class population, and does not acknowledge the complex ways that individuals can be involved in their child's education (Martin, 2006). One finding from Hedeen, Moses, and Peter's (2011) synthesis of the literature on family-school collaboration is "involvement may be too narrow a term to encapsulate the range and depth of partnerships that support students' success" (p. 1). Power differentials between educators and school families may be a barrier to parent engagement. The Southwest Educational Development Laboratory (as cited by Chavkin, 1989) found that 95% of the 1188 parents surveyed between 1980 and 1986 wanted to be active in their children's school. However, parents face barriers that limit their engagement including time limitations, lack of understanding about how to access school and its resources and feeling intimidated by school staff (Metropolitan Life Study as cited by Chaykin, 1989; Osefo, 2017). Strong family-school partnerships are likely to have benefits for all stakeholders including increased student academic achievement, parent engagement, and teacher job enjoyment (Chavkin, 1989). However, school policies often do not make these partnerships accessible to all parents. Because research has shown that parent involvement is beneficial for students, this intervention attempted to minimize barriers that limit strong family-school engagement. Below, several family-school models, including participatory action, are described in light of their potential to increase family-school partnerships at CPS where the research was conducted.

Benefits to parent involvement. Parent involvement is beneficial to all students but is especially important for ethnic minorities and children living in poverty (Epstein & Dauber, 1991). Berry (2008) tested the generalizability of a National Mathematics Advisory Panel finding that parental involvement correlates to student success. Following Martin's (2006) concern that research about math learning does not often consider the experience of Black students, Berry (2008) studied a small sample of Black boys and learned that parents of successful Black male mathematics students played several roles: "(a) guardians of opportunities; (b) standard setters; (c) resources for mathematical knowledge; and (d) models of success" (p. 23). Evidence showed that parental expectations correlated with academic outcomes for both male and female Black students (Archer et al., 2015; Baker et al., 2002; Berry, 2008; Eccles, 2005; Entwistle & Alexander, 1989; Leitch & Tangri, 1988; McNeal, 2014; Noble & Morton, 2013). Researchers have found parent involvement as most effective when situated in family experience (Baker et al., 2002; Bronfenbrenner, 1977, 1986; L. Gutiérrez, 2015; Resnick, 1987) and when it takes a CRT perspective (Baker et al., 2002; Berry, 2008; R. Gutiérrez, 2000;

Ladson-Billings, 1997). Family experience grounded in the transdisciplinary perspective of CRT "uses mathematics as a context to provide the insights and perspectives of African American parents" (Berry, 2008, p. 26). For example, parents might present math as it intersects with the social construct of race through such strategies as storytelling, counter-storytelling, or sharing examples from everyday life (Delgado, 1995).

Another way that Black parents supported their children's math success is by framing math problem solving as an opportunity to master content rather than as an extrinsic reward driven performance (Gutman, 2006; Martin, 2006). Black parents also supported academic success by advocating for their children to learn math that would help them "penetrate closed structures, improve their conditions in life, and overcome the barriers that they will likely encounter" (Martin, 2003, p. 8). Berry (2008) wrote about how parents' social capital supported success for Black boys. Parents communicated the values of education to their children and often continued practices modeled in their own childhoods (Fields-Smith, 2006). Overall, parent involvement in student learning increased students' enjoyment of schoolwork (O'Sullivan et al., 2014), built social competence and helped develop interpersonal relationships that supported learning (Bower & Griffin, 2011; Fields-Smith, 2006). Finally, parent-child relationships were shown to have a greater impact on learners' academic outcomes than parent-school interactions (McNeil, 2014).

Barriers to parent involvement. Barriers to parent involvement are likely to undermine parents' self-efficacy with supporting their daughters as math learners. Increasing the need for this intervention to have a strong family-school partnership component, many of the barriers are contextualized in the relationship between family and school. Cushing and Kohl (1997) described barriers to teachers opening themselves up to collaboration with families including fear of public scrutiny, teaching staff burn-out, and attitudes and perceptions about the school community.

Other research studies have shown that Black parents do not trust that school personnel are invested in their children parents (Berry, 2008; Colbert, 1991; McNeal, 2014; Shriberg et al., 2012). Latunde and Clark-Louque (2016) wrote that while Black parents prioritize learning for their children, many teachers underestimate Black learners. Often White educators and school administrators falsely assume that Black parents are not interested in their children's academic progress (Ho, 2002; Latunde & Clark-Louque, 2016; Snell, Miguel, & East, 2009).

Teachers may treat parents differently and parents may interpret teacher and school policies differently, which also creates barriers to parent involvement (Ho, 2002). Additionally, White and/or middle-class educators may judge Black and/or low socioeconomic status parents based on a perception that their own statuses are based in hard work and personal virtue unmediated by unearned advantages generated by social reproduction (Ladson-Billings & Tate, 2016). One barrier indicated by the literature includes parents' perception that they are marginalized in schools (Baker et al., 2002; Epstein, 1988; L. Gutiérrez, 2015; Shriberg et al., 2012; Yull et al., 2014). Parents who feel left out of the conversation about their children's education are unlikely to feel like valued participants (Remillard & Jackson, 2006). Other impediments to parent involvement include lack of parent time or energy (O'Sullivan et al., 2014), and lack of content expertise (Archer et al., 2015; Baker et al., 2002; O'Sullivan et al., 2014). Even when parents have content knowledge, not understanding the language or approach of the curriculum can be a barrier to parent engagement (Remillard & Jackson, 2006). Another barrier mentioned by the literature is low self-efficacy (Bandura, 1987; O'Sullivan et al., 2014, Van Voorhis, 2011). Parents with high self-efficacy were more likely to establish structures at home to support learners' autonomy with schoolwork or to offer direct assistance (Van Voorhis, 2011).

Parent Self-Efficacy

As mentioned above, the operational theory of change for this intervention was predicated on an increase in parent or family member self-efficacy with supporting their daughters' math achievement. Before introducing the framework and methodology chosen to facilitate the increase of self-efficacy during the intervention, it is important to discuss the construct of self-efficacy in terms of the problem of practice. Bandura (1994) defined self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (p.2). The construct of self-efficacy used here describes a parent or family member's confidence with supporting his or her daughter's math learning within the school context. Low self-efficacy is likely to negatively affect caregivers' ability to engage with their daughters in math learning and to apply knowledge and resources to support their daughters' academic achievement. As an example of this, a PCM parents engaged her children in a wide range of math activities including shopping, cooking, and keeping track of mileage on road trips, but said that she did not know how to help her daughter with math. Another parent described the interactive math activities that she organized at home for her grandchildren. The same parent expressed frustration with helping her grandchildren do homework, "I can't even comprehend half of the stuff they do these days" (Jeter, 2016).

Often, parents want to help their daughters achieve academically, but are not sure how to work within school expectations to do so (Epstein & Dauber, 1991; Epstein & Van Voorhis, 2001; Ho, 2002; Jeter, 2016). Parents and family members with low self-efficacy related to math, or to doing math the way it is presented in school, tend to participate less in math with their children at home (O'Sullivan et al., 2014; Remillard & Jackson, 2006). The research intervention discussed here requires family-school engagement related to math homework. Students will model homework for their parents, which will support self-efficacy for parents and students

(Bandura, 1977). A successful collaboration is likely to result in a mastery experience where caregivers' feel more connected to the school.

Though participation and self-efficacy are distinct variables, the literature supports a connection between the two. Galyon, Blondin, Yaw, Nalls, and Williams (2012) studied the relationship between academic self-efficacy, and engagement in class discussion and academic performance of 165 college students and found that students' self-efficacy levels predicted their levels of class participation, especially for students demonstrating high academic performances. Chang and Chien (2015) also examined academic self-efficacy and student participation. They found a positive relationship between academic self-efficacy and academic participation. Other scholars found positive connections between self-efficacy and participation related to participation in citizenship in Iran (Barati, Abu Samah, Ahmad, & Idris, 2013), the social participation of people with severe mental illnesses (Suzuki, Amagai, Shibata, & Tsai, 2011), and participation in athletic activities (Allison, Dwyer, & Makin, 1999; Daniali, Darani, Eslami, & Mazaheri, 2017; Perkins, Multhaup, Perkins, & Barton, 2008).

Increased perceived self-efficacy—the sociocognitive expectation that one can succeed at a task despite stress—is positively aligned with parent ability to set goals, overcome obstacles, and adjust to new situations (Bandura, 1994, 1997; Jerusalem & Schwarzer, 1992). People with high self-efficacy are more likely to ask for support (Jackson, 2000), and have higher aspirations than those with lower self-efficacy (Rollins & Valdez, 2006). When an individual has self-efficacy, it is also more likely that he or she will persevere at tasks even when setbacks occur (Bandura, 1986). For example, increased self-efficacy might increase the likelihood that a parent persists in finding strategies to help a struggling child. A parent with high self-efficacy is more likely to ask a teacher or another parent for help when they do not understand a problem. Additionally, strong parent monitoring and community cohesiveness support high academic aspirations and self-esteem of children living in high-risk neighborhoods (Cunningham, Hurley, Foney, & Hayes's, 2002). There is also evidence that parental self-efficacy can mediate variables that may otherwise undermine parenting ability including depression, poverty, and low marital support (Teti & Gelfand, 1991).

Self-efficacy here is further defined as a resource (Bandura, 1997; Jerusalem & Schwarzer, 1992), which parents can use to navigate their daughter's success as math scholars. Parental involvement supports children's academic achievement (Archer et al., 2015; Baker et al., 2002; Berry, 2008; O'Sullivan et al., 2014). High parent self-efficacy affects parents' academic aspirations and subsequently influences students' academic achievement (Pastorelli et al., 2001). Several scholars found a positive correlation between parent-school collaboration and student academic achievement (Epstein, 1995; Epstein & Van Voorhis, 2001; Remillard & Jackson, 2006).

Student Math Identity

Solomon (2012) wrote about the difficulty women face when trying to position themselves as mathematicians in a field where a persistent gender bias favors males. Bonilla-Silva (as cited by Martin, 2012) asserted that because

> meanings for Blackness have always permeated the prevailing racial ideologies, institutional practices, social arrangements, and opportunity structures in the U.S. society these meanings are no less relevant to Black children's mathematical development and lived realities. (p. 50)

Martin (2012) wrote about how both empirical and ideological research in education position Black children as mathematically illiterate without attempting to explore the ecological context of their mathematical understanding. Further, he described how Black students' mathematical identity construction includes in-school phenomena such as teacher beliefs, ability judgements, and deficit-thinking, and out-of-school phenomena such as peer interactions. When so many societal and institutional forces are engaged in the construction of one's math identity, what then does it mean to be a Black girl in the context of learning math (Aguirre, Mayfield-Ingram, & Martin, 2013; Martin, 2012)? Were this question put to a group of girls, it is likely that no two answers would be the same. That social identities, such as race and gender, are likely to influence how students learn, should not lead to gender or race essentialism, or the notion that Black girls' experiences are monolithic (A. Harris, 1990). Gender and race intersect in unique ways with individuals' other social group identities and personal traits (Cross, 1978; C. Davis et al., 2006). Still, evidence shows that Black girls may struggle to develop an academic identity in school despite other characteristics including educational, economic, and cognitive ability. Grantham and Ford (1998) studied gifted students and found that the incongruity between some Black girls' home and school environments made negotiating racial and social identities at school difficult; for White girls, school culture was more likely to be an extension of the culture at home.

The definition of math identity used here includes several components. These are a student's (a) beliefs about herself as a math learner, (b) engagement in math learning, (c) perception about how other teachers and students think of her as a math learner, (d) her math self-narrative and aspirations (Solomon, 2009). The theory of change builds on Martin's (2012) idea that identity learning be contextualized within the child's overlapping circles of influence (Bronfenbrenner, 1977). The researcher anticipated that student math identity would increase through doing interactive homework situated between student-family-school. Though the researcher anticipated and desired that participating students' procedural math skills would increase through this intervention, the key outcome anticipated was that each child would build on their deepening conceptual math knowledge to construct a math identity that supported their aspirations.

Conceptual and procedural math knowledge. Procedural math knowledge involves learning skills or processes. Conceptual math knowledge relates more to understanding processes, making connections, and noticing patterns. According to Rittle-Johnson and Alibali (1999), “These two types of knowledge lie on a continuum and cannot always be separated; however, the two ends of the continuum represent two different types of knowledge” (p. 175). While conceptual understanding helps learners develop procedural skills, strengthening procedural skills does not necessarily lead to increased conceptual understanding (Rittle-Johnson & Alibali, 1999). Boaler and Greeno (2000) found that an overemphasis on teaching procedural skills may lead “able students to reject the discipline at a sensitive stage in their identity development” (p. 171).

Rationale for Intervention

Parent engagement has been found to align with stronger academic outcomes for Black girls, which is one rationale for the family-student-school focus for this intervention (Archer et al., 2015; Baker et al., 2002; Berry, 2008; Eccles, 2005; Epstein, 2004; L. Gutiérrez, 2015, O’Sullivan et al., 2014; Van Voorhis, 2011; Yull et al., 2014). Black parents representing diverse educational backgrounds and socioeconomic statuses participated in a focus group as part of the needs’ assessment (see Jeter, 2016). All parents demonstrated at least some activities mentioned in Epstein’s (2011) six types of involvement, including volunteering, making math connections at home, and communicating with teachers. However, parents were less confident about how to leverage their own math knowledge to help their daughters succeed in school. Parents gave several reasons for their lack of confidence including (a) lack of familiarity with the Montessori math procedures, (b) low confidence in their own math knowledge, and (c) confusion about modern math (Jeter, 2016).

Unlike parents at PCM who mentioned that homework would help them feel more connected to what their children do at school, students at CPS were already given homework each night. This homework takes the form of a packet where students complete several problems each night. Neither school offers consistent opportunities for parents to partner with the school related to academics. This researcher intended to support students as math learners by contextualizing their math experience within stronger family-school partnership support. An increase in parent self-efficacy with supporting daughters and an increase in math skills were desired mid-term outcomes for this research. The long-term educational outcome was that the student participants develop stronger concepts of themselves as math learners. A belief about belonging in the math community, can make a powerful difference in math performance as well as the level of math opportunities sought in the future (Bishop, 2012; Phan, 2013; Tschannen-Moran et al., 2013). Many factors contribute to Black girls' mathematical success—self-efficacy, a high-level of math skills, growth-mindset, math identity, and persistence to name a few. The researcher chose to focus on math identity, without which even a mathematically gifted student was less likely to have a sense of belonging in math environments, to take the higher-level math classes that could lead to more lucrative jobs or advanced STEM degrees.

Literature Review of Frameworks and Interventions

Abundant mention of interventions that target the actionable constructs—parent self-efficacy and family-school engagement—existed in the available research literature. Though few of these studies addressed interventions for the math underperformance of Black girls, the literature did provide some guidance about intervention strategies that might be applied to the research intervention conducted here. A description of family-school models including relevant interventions will follow an explanation of the two key frameworks used: CRT and Bronfenbrenner's (1977) socioecological theory.

Critical Race Theory and Education

One assumption of CRT is that the racism present in a society is also present within a classroom or school. An implication of this perspective is that racism is a salient aspect of education in city schools like PCM and CPS. Further, the CRT framework holds that the racism present in society is present in the family-school relationship. For example, racism may undermine parents' confidence in their abilities to apply what they know about math to math work associated with their children's school. Racialized experiences may make parent-teacher relationships more challenging. Researchers have used CRT as a tool to understand issues better, including tracking, testing, discipline, and how to integrate multicultural education into the curriculum (Delgado & Stefancic, 2012; Ladson-Billings & Tate, 2016; Yosso, 2005). Applied to education, tenets of CRT are that "(a) race is a significant factor for determining an inequity, (b) the U.S. is based on property rights, (c) race and property provide an analytical tool for understanding social, school, and mathematics inequity" (Ladson-Billings & Tate, 2016, p. 48). In CRT, analysis of race and power in the educational context should lead to resolving injustices with transformative action (Delgado & Stefancic, 2012; Yosso, 2005). CRT must challenge the dominant ideology and assumptions by addressing the intersection of oppressions in both school community and curriculum (Solórzano, 1998). Pedagogically speaking, teachers could use an interdisciplinary approach that relies on learning through experience (Solórzano, 1998). Ladson-Billings (1998) cautioned educators about appropriating a CRT framework without understanding how it is contextualized in the legal literature. She posited that using a CRT framework requires not only exposing racism, but also finding solutions to address it. Ladson-Billings (1998) wrote the following:

> CRT in education is likely to become the "darling" of the radical left, continue to generate scholarly papers and debate, and never penetrate the classrooms and daily experiences of students of color. But, students of color, their families, and communities cannot afford the luxury of CRT scholars' ruminations any more than they could afford those of critical and postmodern theorists, where the ideas are laudable but the practice leaves much to be desired. (p. 22)

Bronfenbrenner's Socioecological Theory

Bronfenbrenner's (1977) socioecological theory was an attempt to "'control in' as many theoretically relevant ecological contrasts as possible within the constraints of practical feasibility and rigorous experimental design" (p. 513). Rather than viewing an event from one artificial perspective that cannot be generalized to another context, the socioecological model permits the observer to analyze the bidirectional and nuanced perspectives that occur when different levels of experience intersect (Bronfenbrenner, 1977).

Bronfenbrenner's (1977) systems include the microsystem, mesosystem, exosystem, macrosystem, and the chronosystem (see Appendix H). The microsystem includes the relationships closest to an individual, including family or close friendships. At the next level, the mesosystem includes the interactions or relationships between two or more contexts in the microsystem. Indirect influences on the microsystem include the loss of a parent's job or a divorce, which are categorized as the exosystem. The macrosystem includes the cultural beliefs, ideological influences and social constructs that may influence the individual's life. Finally, the chronosystem contains the sociohistorical events that occur across time.

A systems approach supports understanding of phenomena within the intervention for the math underperformance of Black girls. In the context of this intervention, there are at least two microsystems, the family and the school. One example of a mesosystem might be interactions between home and school, or on a more abstract level, between the child's school identity and home identity contextualized in either home or school. The exosystem would include the school administration, a parent's job, or relationship. Examples of the macrosystem include housing policies, racism—both historical and current, and federal education policies. Finally, the chronosystem: this is a longitudinal description of girls' math learning as they move through elementary school to middle school, and eventually toward a career. As one considers the children contextualized by these multi-directional systems of influence it is valuable to note that each girl's demand, resource, and force are unique (Bronfenbrenner, Morris, Lerner, & Damon, 2006). The child exists in the intersection of these overlapping spheres of influence, and the bidirectional relationship is influenced by the child's individual characteristics.

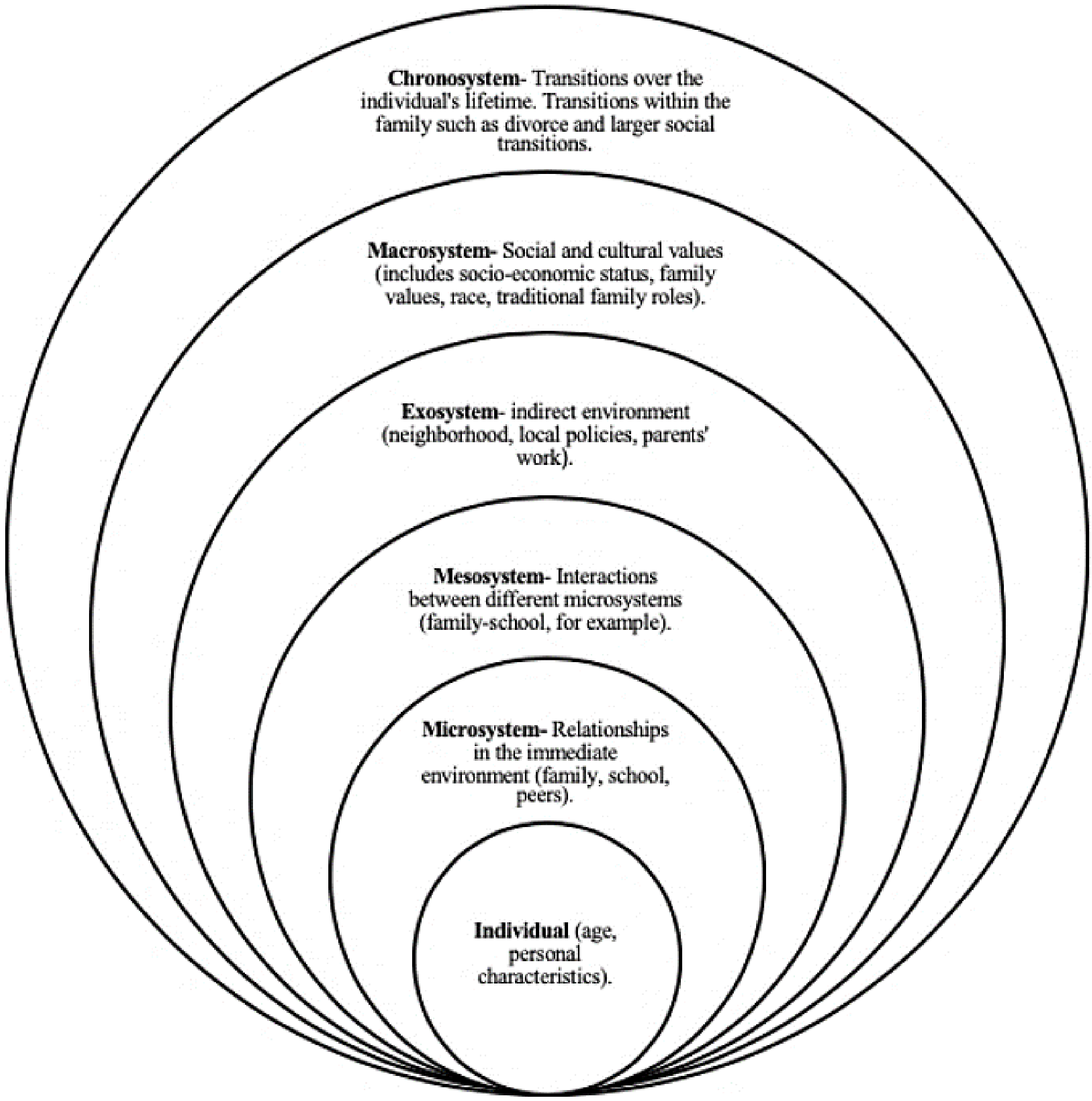

Figure 2. Bronfenbrenner's socioecological model.

Family-School Models

Each of the following family-school models aligns with the National Education Association's (2016) requirement that family-school collaboration be an active partnership that supports student learning; however, each model was created with a somewhat different objective. Every Student Succeeds Act's (2015) parent and family engagement plan is a mandate written by the U.S. Department of Education (2016). Epstein's (1988) framework of six types of involvement is an evolving framework that has been replicated and adapted often over the years in many educational contexts. Epstein's (1988) seminal framework has been widely used by educators and has influenced parent-school engagement documents including one distributed by the NEA (2011). As a member of the National Network of Partnership Schools, situated at Johns Hopkins, Epstein (1988) works with schools, districts, and other organizations to promote "research-based and goal-oriented programs of school, family, and community partnerships" (Partnership Schools, 2017). Third, a participatory action research framework is introduced. If, as Hedeen et al. (2011) said, "collaboration can be defined as either a process or an outcome" (p. 1), participatory action is primarily known for its collective process of inquiry and social action. Participatory action research has been used by educators, including Moses and Cobb (2001), and has been used to legitimize the cultural capital of many people in diverse community settings.

Bolívar and Chrispeels (2011) wrote that many family-school interventions fail to consider the complex power differentials that exist within the school community. If parents attend decision making events, their role is often limited to modifying or approving decisions made by the school (Bolívar & Chrispeels, 2011). As an example of this, Bryan and Henry (2008) wrote about a parent involvement committee that met specifically to foster family-school collaboration. Comprised of nine teachers and one parent (also a teacher's assistant), this group planned events for families, including Red-Ribbon Week, Read and Feed Night, and a Black History Concert. Families participated by attending the event but had no decision-making power.

Every Student Succeed Act

Every Student Succeed Act's (ESSA, 2015) parent and family engagement program moves beyond a traditional (Epstein, 2011) approach to family-school collaboration to support education. ESSA is a Federal program that gives school districts some accountability and flexibility about how to encourage family-school partnerships. To receive funding, school district leaders must include the families of students in planning and implementing programs, procedures, and activities that are relevant to that community (ESSA, 2015). The ESSA (2015) guidelines mandate that schools must meaningfully involve parents and family members to (a) jointly develop a district plan, (b) build school capacity, (c) link school family engagement programs to relevant programs at the local, state, and federal levels, and (d) conduct annual evaluations to assess the effectiveness of current policies. One percent of Title I funding where one percent of the funding is $5,000 or less, must be allocated to individual schools to help them implement and carry out family engagement activities (ESSA, 2015). At the level of the school, ESSA (2015) requires a bi-directional parent-school compact that determines how both parties will be responsible for increasing student academic achievement.

The ESSA (2015) gives parents and family members a clear idea of how to be involved in their child's school which is something that the research shows that parents want (Ho, 2002; Hoover-Dempsey et al., 2001). The ESSA (2015) offers a thorough outline of strategies intended to promote parent-school partnerships and improve student academic achievement. ESSA gives school districts some autonomy and offers parents options for participatory involvement. For example, ESSA requires some parental participation on advisory boards that make decisions about children's education. ESSA also asks parents to work with their school to create a parent involvement plan. The plan must (a) include strategies to overcome barriers that limit parent involvement, and (b) coordinate parent involvement at the school. It is not clear how these decision-making roles are influenced by power differentials within the school community (ESSA, 2015).

Epstein's Framework of Six Types of Involvement

Compared to the legalistic model set forth by the ESSA (2015), Epstein's (1988) framework of six types of involvement (Epstein & Salinas, 2004) conceptualizes family-school collaboration within Bronfenbrenner's (1977, 1986) socioecological model to support student growth. One belief that emerges from taking the perspective that children develop within the intersecting spheres of family, school, and community (Epstein & Van Voorhis, 2001; Epstein & Salinas, 1995, 2004; Epstein & Sheldon, 2006) is that schools demonstrate that they care about students by caring about students' families and communities (Epstein, 1995). By applying the theory of multiple influences to students, Epstein's (1995) model of involvement acknowledges that learning is the responsibility, not of one individual, but of the community.

Epstein and Sheldon (2006) questioned, "How can more families – indeed, all families – become involved in their children's education in ways that contribute to student success" (p. 117)? The six types of involvement included (a) taking care of the child's basic needs, (b) communicating with the school, (c) volunteering, (d) learning with the child at home, (e) assisting school decision making, and (f) collaborating within the larger community. Epstein's (2004) framework encourages a relationship building process that includes engagement with families and communities. This process places emphasis on the reciprocal relationship between schools and families (Yull et al., 2014), which may protect against barriers to parent involvement mentioned in the section above. Other research showed that Epstein's Framework presented barriers to collaboration with Black or Latino populations in high-poverty schools (Bower & Griffin, 2011; Latunde & Clark-Louque, 2016). Harry, Kalyanpur, and Day (as cited by Latunde & Clark-Louque, 2016) wrote that Epstein's (2004) framework offers ways for schools to identify parental involvement and specific areas to target for improved involvement. However, "Epstein's model has become a checklist for schools and lacks a cultural lens through which the intersections of race, ability, disability, income, and education can be examined" (Latunde & Clark-Louque, 2016, p. 72).

Participatory Action Research

Participatory action research (PAR) situates learning in the community, and positions families as active participants in research (L. Gutiérrez, 2015; Shriberg et al., 2012). In PAR, community members and researchers partner to lay the groundwork for effective collaboration, devise methodology for gathering data, and then analyze and revise data. Such alignment is likely to increase the chance that project implementation will be successful and sustainable, and inclusive (Evans, Thornton, & Usinger, 2012). The research literature supports PAR, indicating a preference in Black families toward collaboration (Berry, 2008; Boykin, 1986; Gutman, 2006; Sankofa, Hurley, & Boykin, 2005; Yull et al., 2014).

The inclusion of diverse stakeholders ensures that multiple perspectives about a problem are shared. and may minimize the implicit bias of individual participants. The PAR process engages participants as coresearchers rather than limiting their role to objects of research (Bergold & Thomas, 2012; Dotson-Blake, Foster, & Gressard, 2009; Gutierrez, 2015; Livingstone, Celemencki, & Calixte, 2014; Shriberg et al., 2012; Yull et al., 2014).

Having coresearchers share the personal beliefs and experiences that contextualize their experience at CPS would have been one way to legitimize Black families' cultural capital within the intervention (Bourdieu, 1986; Lareau, 2011). PAR would have also offered an opportunity to understand girls' coping mechanisms as they relate to math learning (Boykin, 1986; Bronfenbrenner, 1986; Ladson-Billings, 1997; Resnick, 1987; Sankofa et al., 2005).

Summary of Family-School Engagement Models

ESSA's (2015) family-school macro-structure provides a framework for establishing school or district-wide norms that increase engagement within a community or institution. District and state educators are given the flexibility to interpret ESSA to suit local schools and communities. Further, the ESSA model requires schools to include parents at each administrative level. ESSA was not a pragmatic choice for this small- scale intervention where the researcher did not have the leverage to influence family-school partnerships at the institutional level. A family-school engagement model that would be more appropriate to a small-scale intervention, PAR, encourages the introduction of diverse stakeholder perspectives into the decision-making process. Using these perspectives and ideas to collaboratively build an intervention could add accountability to efforts to increase equity (Gold, Simon, & Brown, 2002). However, even where individual parents would like more of a decision-making role within the school structure, some may not have the resources to engage at that level. Designing research for a few parents who can afford to spend time at school would come at the expense of all families—including some with the greatest need for academic support—does not serve the school community well. The researcher decided that for the initial intervention study a PAR paradigm would not give enough access to all families.

Epstein's (2004) framework of six types of involvement (Epstein & Salinas, 2004) seemed more appropriate for guiding a small family-school homework pilot program. Epstein and Sheldon's (2006) reminder that children learn within a sphere of influences is relevant to the planned research study's hypothesis that increased parent self-efficacy is likely to positively correlate with student academic achievement. Epstein's (2004, 2011) found that many parents' greatest school-related concern is supporting their children's academic achievement at home. Epstein's (2011) six levels of family-school engagement was chosen for this intervention. Epstein's (2011) interactive homework model, TIPS, was designed by teachers and researchers to help all parents become more engaged (Dauber & Epstein, 1993; Epstein, 2011).

Synthesis of the Intervention Literature

The interventions reviewed below fall into three categories: (a) community-school, (b) situated in everyday life, and (c) interactive homework. These interventions provide justification for using TIPS, an interactive homework model, to increase parent self-efficacy with supporting Black girls as math learners. Robert Moses' work with the Algebra Project, both situates math in everyday experience, and relies on community-school relationship building. The Algebra Project and other math-based interventions connect math to everyday life (Emdin, 2010; Moses & Cobb, 2001; Warren, Ogonowski, & Pothier, 2005). Others recommended situating mathematics in the contexts of student's social, cultural, and family life (Cobb & Bowers, 1999; Delgado, 1995; Ladson-Billings, 1995). Finally, an interactive homework intervention is reviewed, TIPS (Epstein & Van Voorhis, 2001). TIPS situates learning within the family-school bi-directional relationship, and connects math learning to everyday experience. TIPS does not include parents in decision-making, but make engagement accessible for a wide range of families (Epstein & Van Voorhis, 2001).

Community-school Interventions

The Algebra Project. The Algebra Project, framed in the perspective of the Civil Rights Movement's Mississippi Summer, is Robert Moses's attempt to provide access to Algebra to every middle school child including those who are not traditionally on an advanced math track (Moses, Kamii, Swap, & Howard, 1989). Building on Ella Baker's community activism example and on the idea that math is a civil rights issue, Moses et al. (1989) organized a participatory action research model where community members use math as an organizing tool to support math excellence. Over approximately 30 years, Moses and Cobb (2001) expanded the Algebra Project, from teaching students at his children's school in Boston to cities across the United States including the city where this research is situated. Originally, the curriculum was typically used in schools with a high percentage of Black students; today the program is used with students from different racial and ethnic backgrounds.

The original Transition Algebra Project curriculum addressed barriers to student understanding of the conceptual framework upon which Algebraic thinking depends. For example, students typically think of numbers in their capacity to answer the questions quantitatively. However, Algebra also requires students to think of numbers qualitatively in terms of their ability to answer questions like, "In which direction? (Silva, Moses, Rivers, & Johnson, 1990, p. 380). The five-step curricular process requires students to (a) establish a physical basis for the algebraic concept, (b) make a model of the algebraic concept, (c) provide “intuitive” language to describe the algebraic concept, (d) connect intuitive language to standard mathematical language, and (e) represent the concept using symbols (Silva et al., 1990). Thus, the curriculum provides a scaffold that helps students connect everyday experience to algebraic concept. The Algebra Project’s success with helping students learn –many considered to be incapable of understanding Algebra –may build on its use of everyday experience and a CRT perspective. The perspective that math should be socially constructed is another aspect of the Algebra project that aligns well with both Montessori pedagogy and this intervention. Three goals established by the Algebra project are relevant to this intervention:

> To develop highly motivated, mathematically literate (middle school) students able to succeed in college preparatory courses at the high school level; to reform middle school math instruction so that it is relevant to student lived experience and their socially constructed knowledge-base; and to organize supportive communities which understand “math education as a problem of mathematics literacy” and student capability “as a matter of effective effort.” (Silva et al., 1990, p. 37l)

The impact of the Algebra Project on student math achievement has varied. Several independent studies reported a significant effect on state tests measuring Algebra proficiency when classrooms or schools adopt the Algebra Project curriculum (Cazden et al., 1995; F. Davis & West, 2000; West, Davis, Lynch, & Atlas, 1998). A longitudinal study with a sample size of approximately 500-550 sixth through eighth grade students from 1990-2005 found that students with a teacher trained in the Algebra Project curriculum and pedagogy were significantly more likely to enroll in higher-level math classes in high school (West & Davis, 2006).

Dubinsky and Wilson (2013) studied the effect of a 7-week treatment using Algebra Project materials and pedagogy on twenty high school students’ conceptual understanding and practical skill with function problems. All but two of the students qualified for free-or-reduced lunch. These students were selected based on their low performances on standardized math test, the Florida Comprehensive Achievement Test (FCAT). Students must make a score of 3 (on a scale of 1 to 5) on the 10th grade FCAT to graduate from high school. Although 10th-grade data were not available to the researchers, 13 of the students had a score of 1 on the 10th-grade test, and two had a score of 2. The students did not have a strong understanding of integers and "were apparently considered by the school to be hopeless and not capable of high performance" (Dubinsky & Wilson, 2013, p. 83) when they started.

After 7-weeks, students recognized and explain the concept of functions and were also reasonably successful at completing function work on par with beginning college students. One troubling threat to the internal validity of this study is that a comparison of participants' pre and postmeasures did not include a control group. Additionally, the sample size was small, with an attrition rate of five. However, the mixed-method evidence showed that something happened in the Algebra Project's Black box treatment that moved the target group participants from a place where very little was expected of them as math scholars to one where they approached complex math problems.

Leaders of other schools have achieved less success. Martin (2000) described the failure of the Algebra Project at Hillside school which was marked by the organizers inability to engage both students and parents. Classroom behaviors made it difficult to implement the curriculum with most students either acting out or not applying themselves. Speaking about the failure, Martin (2000) called the connection between school, parents, and community "the conduit" (p. 187) for making math learning salient for Black youth.

The Algebra Project is included here because it demonstrates how important family-school partnerships can be to learning. Including family members as active collaborators, including community participants in leadership roles, and advocating to contextualize the project within the overlapping spheres of students' lives in the neighborhood are strategies that make the program successful (Moses et al., 1989). In an educational system with historical and persistent race, gender, and socioeconomic based inequities, adapting the Algebra Project's inclusion of stakeholders at various levels will help ensure that solutions are grounded in multiple understandings of the overlapping bio-ecological systems of CPS students (Bronfenbrenner, 1977).

Interventions that connect math to everyday life. Because parents in a focus group (Jeter, 2016) mentioned a disconnection between "their math" and "school math," it made sense to look at interventions that contextualize learning in "real-life." This approach has also been recommended by CRT advocates (Delgado, 1995; Ladson-Billings, 1995). It is relevant to ask whether tasks that allow authentic activity that parents can relate to are available in the classroom (Brown, Collins, & Duguid, 1989). An intervention that attempts to connect students' lives and math acknowledge the diverse social identity constructs and life experiences of families (Cobb & Bowers, 1999). Emdin's (2010) qualitative study attempted to give youth of color an opportunity to express hip-hop culture and consequently minimize alienation in the science classroom. Positioning hip-hop as cultural capital and a complex system of understanding, Emdin wrote about ways to utilize specific constructs within hip-hop and hip-hop culture to science learning. One hip-hop practice that Emdin extended to science learning is the cogenerative dialogue where participants collectively contribute to a conversation until consensus is reached (Emdin, 2010).

Warren et al. (2005) explored how everyday sense making mechanisms could be re-conceptualized to align rather than conflict with academic science learning. They observed an exploration of Newton's Laws using toy cars by first and second grade Black and Haitian-American students. They noticed that understanding was more likely to occur when children connected scientific principles to lived experience. Moses and Cobb (2001) utilized this notion by taking students on a train ride that traveled in a two-directional line from the point of origin. Students used that experience to better understand the concept that integers have both magnitude and direction. Moses and Cobb (2001) based the Algebra Project curriculum on the premise that connecting students' experiences and intuitive language to math concepts and language would support academic achievement; the students scored significantly higher than a control group

Some dispute the assertion of cognitive psychologists and educators who claim that situating learning in everyday experience is beneficial to math learners. J. Anderson, Reder, and Simon (1996) argued claims about the benefits of situated education are overstated. Specifically, they debunked claims made by some cognitive psychologists that advocate for situated learning including the ideas that (a) action is grounded in the context where it occurs, (b) understanding does not transfer from one to another task, (c) abstract training has little value, and (d) learning should be contextualized within a sociocultural context (J. Anderson et al., 1996). Though there is not time here to discuss the specific details of J. Anderson et al.'s (1996) argument, an overview of his position will better clarify the perspective of this intervention. J. Anderson et al. (1996) posited that just as cognition is "partly context-dependent, it is also partly context-independent" (p. 10). It would be difficult to dispute their further assertion that "while there are dramatic failures of transfer, there are also dramatic success" (J. Anderson et al., 1996, p. 10). They made a strong case for the need for both abstract and concrete learning experiences and reminded educators that not all lessons are strengthened by being contextualized in social experience. Educators must balance these polarities to support the physical, social, emotional, and cognitive development of learners within that educational context. Montessori (1917) wrote that mathematics learning should bridge from concrete to abstract in accord with students' developmental readiness. Her insistence that children go into the world to have real experiences was supported by her dictate that they learn abstract operations (Montessori, 1917). At PCM, a Montessori school, there is a natural draw toward this balance which will inform the homework-based intervention discussed here.

Homework. Unlike PCM where the needs assessment was conducted, CPS gives daily math homework to fourth-grade students. Homework is one potential source of family-school involvement related to curricular content. However, the level of parent engagement on homework is hard to determine. When family-school or family-child math related engagement occurs, this engagement is arbitrary and likely to be inconsistent. There is no structure ensuring that families interact with students and school around math learning. The intervention structure makes interactive homework, or homework that encourages family-student-school interaction, a key element of math learning. TIPS is an interactive homework design created by Epstein and Van Voorhis's (2001) that has been used over the past decade in diverse contexts. Below is a review of relevant literature found about TIPS.

Teachers involve parents in schoolwork. Epstein and Van Voorhis's (2001) intervention, connects families and schools through interactive homework. TIPS homework contextualizes math learning in the mesosystem where family and school interact (Bronfenbrenner, 1977). Though TIPS requires less parent and community-level decision-making than a participatory action intervention like the Algebra Project might, parent feedback is incorporated. Below is a rationale for TIPS followed by a description of the process used to implement TIPS. Research about TIPS in different educational contexts—especially related to its role to increase academic outcomes, parent self-efficacy, and family-school partnerships—follows.

Rationale. The National Network of Partnership Schools at Johns Hopkins University has worked for decades to support school, family, and community partnerships that increase student achievement. The organization utilizes Epstein's (1988, 2004) model of six types of family-school engagement which positions the child within overlapping spheres of family and school (Epstein, 1987). Epstein's (1987) ecological treatment of family-school treatments is influenced by Bronfenbrenner's (1977) theory of bio-ecological systems, which posits that human development occurs within overlapping environmental systems (see Appendix J). TIPS interactive homework relies on this ecological framework to contextualize academic content between home and school. Epstein and Dauber (1991) found students reported greater feelings of enjoyment when parents were involved in homework. Parents reported higher feelings of satisfaction with TIPS compared to a traditional homework model. Additionally, students demonstrated a higher level of homework completion (Epstein & Van Voorhis, 2001). Van Voorhis (2011) found a range from $d = .23$ to $d = .49$, indicating small to medium effects with students who had participated in TIPS for 1 to 2 years on student standardized test scores compared to students who had not participated in the TIPS program. TIPS is the intervention chosen here for several reasons. First, TIPS is framed by an ecological family-school engagement model that aligns with what parents said they would like at a focus group and through anecdotal conversations (Jeter, 2016). Second, it is anticipated that establishing a family-school partnership related to curricular content will increase congruity between home and school environments enabling children to feel that they are supported as math learners within the classroom (Grantham & Ford, 1998).

Process. Originally, three schools agreed to participate in the research. One school was to have been the primary focus with both a treatment and control classroom. That school, with predominately Black students from low-socioeconomic backgrounds, was intended to be the site of treatment and control focus groups. Each of the other schools would have been selected randomly through a blind drawing to be either control or treatment. However, adjustments were made to accommodate the loss of two of the participating schools. After having met with the target school math teacher several times, no permission was collected from families making further research with that school untenable. Left with one school—the school receiving only the treatment condition—adjustments were made to the research design (as will be described in Chapter four). The homework contains the following seven steps. The students received 12 TIPS homework assignments over the course of 6 months or biweekly homework.

1. The “Letter to the Parent, Guardian, or Family Member” briefly explains in one sentence the topic and skill of the assignment. The student writes in the due date and signs the letter.
2. The “Look This Over” section shows an example of the math skill taught in class along with the answer.
3. “Now Try This” includes another example for the student to demonstrate the skill of the assignment with the answer on the back of the page.
4. “Practice” includes regular homework problems for the student to master the skill.
5. “Let’s Find Out” allows the student and often the family partner to discover and discuss how the math skill is used at home or in common situations.
6. Two-way forms of communication are encouraged in the “Home-to-School Communication” section that invites the family partner to send an observation, comment, or question to the teacher about the skill demonstrated and the homework experience.
7. Finally, a parent/guardian signature is requested on each activity (Van Voorhis, 2011, P. 321).

Select research about TIPS. TIPS has been used with different age groups to support learning in different content areas. It can be adapted to different curricula. Van Voorhis (2011) tested the effect of TIPS on elementary school students’ math outcomes, emotions and attitudes, and family involvement. Her longitudinal, quasi-experimental study collected data on 153 students from four urban elementary schools in three conditions. The control group did not use TIPS, while the two treatment groups used TIPS for either 1 or 2 years. Van Voorhis (2011) used standardized math achievement test data to reject the null hypothesis for both treatment groups. The confidence level after 1 year with TIPS was 95%; after 2 years, the confidence level was 99%.

Another research study studied the effect of TIPS with different levels of parent participation. Balli (1995) studied the effect of TIPS homework on 74 suburban middle-school children. In this mixed-methods study, three classes had the same teacher and were given identical homework. One class was required to have parents participate, comment on, and sign the homework. In the second class, students were asked to include their parents, but parents were not required to comment on or sign the assignment. The third class was not asked for family involvement at all. Parents in the full participation group felt most involved in their child’s math homework, but parents for both participatory groups felt more involved than parents in the control group (see Balli, 1995; Van Voorhis, 2011). Results also showed that after controlling for past report card grades, students in the TIPS group made higher grades.

Overview of the Proposed Intervention

Using a CRT framework as a theoretical departure point, the intervention is grounded in the idea that racism as it intersects with sexism and other oppressions undermines Black girls’ access to educational opportunity (Bell, 1976a; Crenshaw, 1995; Ladson-Billings, 1995; Solórzano, 1978). Neither a unique or situational occurrence, racism influences each of the overlapping spheres (Bronfenbrenner, 1978) that contextualize the lives of students, teachers, and parents (Crenshaw, 1995; Solórzano, 1978). One assumption of this study is that the math underperformance of Black girls is an effect of opportunity gaps created and manifested by institutional systems and oppressions. One objective of this research involved increasing Black girls’ opportunities to learn math.

The causal model for an intervention to address math underperformance by Black fourth-grade girls at CPS hypothesized that increased family-school engagement through biweekly interactive homework would correlate with increased parent self-efficacy with supporting their daughters as math learners, increased student achievement, and subsequently, student math identity. A pragmatic paradigm was used to allow the researcher to collect mixed methods data to both describe participants' behaviors and make statistical inferences about the effect of the program (Tashakkori & Teddlie, 2003). The researcher collaborated with the classroom teacher to choose 12 TIPS homework assignments that align with the fourth-grade math curriculum. The fourth-grade students were given the TIPS homework, which involved a triadic communication between parents, students, and the teacher. In the original research design, the control group students would have been given 12 homework assignments aligned with those in the treatment group, but without the interactive component.

Teachers in each group would have implemented the homework in similar ways (including the amount of time allowed to complete homework and the amount of time spent in class to introduce and review homework). For this pre and post intervention, there was no control group. The fourth-grade teacher, who chose the pseudonym of Ms. Vader, distributed, collected, and reviewed homework. All students were given 2 weeks to complete the TIPS homework. Parents could give feedback on each homework task, which the teacher used to improve homework as appropriate.

Conclusion

The research intervention engaged families, students, and school in TIPS interactive homework (see Epstein & Van Voorhis, 2001). Expected outcomes of biweekly engagement in this interactive homework included increased parent self-efficacy with supporting their daughters as math learners, increased student grades, and increased student sense of self as a math learner. The intervention was contextualized in a CRT framework and used a pragmatic paradigm. The research hypothesis was that family-school participation in biweekly TIPS math homework would increase parent self-efficacy with supporting their daughters as math scholars as well as student math achievement. It was predicted that these increases would correlate with increased student sense of self as a math learner. In the next chapter, the methodology for implementing and evaluating the intervention are described.

Chapter 4

Procedure and Program Evaluation

Focus group parents expressed a need for a consistent family-school partnership focused on supporting students academically (Jeter, 2016). Based on the literature analysis and needs assessment, the researcher chose an embedded design research intervention where family-school collaboration was anticipated to increase opportunities for the target population to learn math. TIPS interactive homework was chosen to contextualize participating children's math learning in in both home and school. TIPS also allowed for the interactive homework modeling and mastery experiences likely to increase parent self-efficacy related to supporting their children at school (see Bandura, 1997).

First, the researcher anticipated that participation in the intervention would increase parents' self-efficacy with supporting their daughters as math learners. The literature showed support for increased parental self-efficacy leading to parents doing more math related activities with their daughters (Epstein, 1995; Epstein & Van Voorhis, 2001; Fields-Smith, 2006; O'Sullivan et al., 2014; Pastorelli et al., 2001; Remillard & Jackson, 2006; Van Voorhis, 2011). Researchers have shown family expectations and support to correlate with high-math achievement for Black students (Archer et al., 2015; Baker et al., 2002; Berry, 2008; Epstein & Dauber, 1991; Entwistle & Alexander, 1989; R. Gutiérrez, 2000; Ladson-Billings, 1997; Leitch & Tangri, 1988; McNeal, 2014; Noble & Morton, 2013). The second prediction was that family-school-student participation would increase students' math scores on a skills-based test (see Dauber & Epstein, 1993; Epstein & Van Voorhis, 2001; Resnick, 1987; Van Voorhis, 2011). Third, the researcher anticipated this intervention would increase girls' sense of themselves as learners of mathematics, subsequently leading them to seek challenging math opportunities now and in the future (see Aguirre et al., 2013). The following sections contain a rationale for this research study, research implementations and evaluation processes, and methodology for the project.

Study Rationale

Parents who participated in the needs assessment focus group described how they supported their children's math learning at home; they expressed low self-efficacy about whether these at-home practices supported math achievement at school (see Jeter, 2016). The researcher chose to address this expression of low parental self-efficacy with supporting their daughters as math learners through the research intervention. Another salient factor to emerge from the focus group was parents' desires to develop a stronger family-school partnership related to curricular content (see Jeter, 2016). Though findings from the needs assessment at PCM might not be generalizable to the intervention at CPS, personal communications with the CPS fourth-grader teacher and head of school indicated CPS was interested in strengthening family-school communication. These factors supported the choice of the current homework-based intervention, Epstein and Van Voorhis's (2001) TIPS (see Appendix C for an example of TIPS homework). TIPS was chosen as a conduit through which families and teacher might interact with students to support math learning, TIPS is also accessible to a broader range of parents including those unable to commit time to activities situated in the school building. A participatory action homework intervention might have engaged parents at a higher decision-making level, but TIPS can help minimize one barrier to family-school collaboration—lack of time (O'Sullivan et al., 2014).

Building on previous research interventions using TIPS, the focus here was to learn more about the connection between homework focused on family-school partnership and student math identity. In other words, does contextualizing math learning within the overlapping spheres of home and school increase students' sense that they belong in math learning environments? Data collected from this intervention may also increase understanding about how to implement future homework-based initiatives at the classroom and school level. Though the research focused on the experience of Black girls, all students participated in the intervention. During analysis, data were aggregated by race and gender. The original plan was to also conduct pre and post intervention focus groups to gather information about the intervention process from control and treatment groups of parent and student participants. However, due to changes in participating schools, only a postintervention focus group was conducted. Experiential data about the intervention process, and gathered from the focus group, drew on the experience of four Black fourth-grade girls and their parents.

Renganathan (2009) wrote about "the blurred boundaries associated with being neither a complete insider nor outsider" (p. 11). During the needs assessment, the researcher played this dual role when she conducted research at PCM where she worked as a teacher. A school community insider, her identity as a White woman whose children did not attend PCM also positioned her as an outsider. The researcher collected and analyzed data from a dual perspective which resulted from holding both of these roles. The parents participating in the focus group had diverse socioeconomic and educational levels but shared the lack of access to PCM teachers or administrators who shared their racial identity. The original plan that the research intervention take place at PCM was disapproved by Urban Districts' Office of Achievement and Accountability IRB for the protection of human subjects who would not allow the researcher to conduct research in the same institution where she had students. It was necessary to find a new research site which ultimately ended up being CPS. In the work done with CPS, the researcher played only an outside role.

The researcher considered whether a shift in intervention sites from PCM to CPS would necessitate changes to the intervention plan. CPS is in a more affluent neighborhood than PCM but has a higher number of children from low-socioeconomic status families (Niche, 2019). CPS also has a higher rate of students who performed at the proficient level on the PARCC. PCN had

22% of overall students, 4% of Black, and 31% of White students compared to CPS with 33% of overall students, 16% of Black, and 32% of White students performing at a proficiency level. The researcher decided that the research intervention would be appropriate for either school, and no significant modifications needed to be made. To compensate for a class where many students, particularly the Black girls, were high achievers, the researcher did work with Ms. Vader to ensure that the homework was challenging. When the researcher first saw students' year-long grades, three-fourths of the focus group members had made straight Es (the highest score possible); this finding made it necessary to add a qualitative component when measuring whether students' math achievement had increased.

Intervention Research Questions

RQ1. In what ways does participation in the TIPS home-based math intervention influence parental self-efficacy to support their Black girl's math learning?

RQ2. In what ways does participation in a home-based math intervention influence students' math identity?

RQ3.Over the course of the intervention, how do Black female students' descriptions of themselves as math learners converge with their academic scores?

Research Design

Treatment Theory

Unlike a Black box approach, treatment theory makes the mechanisms of an intervention process visible (Leviton & Lipsey, 2007). By differentiating the research paradigm as it applies to the specific context of the research, treatment theory "supports the construction of differentiated concepts about the processes involved" (Leviton & Lipsey, 2007, p. 33). Where logic models describe the details of the research intervention, a treatment theory contextualizes the research study within events that are likely to influence the outcome. Here, the treatment theory was applied to 40 fourth-graders and their parents. The original research design included a control group of fourth-graders from another elementary school classroom, as well as two classes (control and treatment) at a third site (140 students in all). The teacher at the second site could not collect IRBs, and the teacher at the first site did not communicate with the researcher after having submitted a letter granting permission to conduct research. Hence, the intervention involved only CPS (40 students), and no comparison group was available. The intervention involved a parent-school partnership with students-parents-and teachers interacting on biweekly TIPS homework assignments. Participation in this intervention was expected to increase parent self-efficacy with supporting their daughters as math learners and student math achievement. These mid-way outcomes were expected to lead to a long-term outcome of increased student sense of self as a math learner. Careful representation of the small theory of this research project (see Appendix D for treatment theory model) was expected to increase the chance that research findings accurately described the intervention's effect on parental self-efficacy and subsequently, student math achievement.

A pragmatic paradigm is oriented in real world practice and acknowledges that the research is situated in social, historical, and political contexts (Creswell, 2014). The "small theory" of this research (Leviton & Lipsey, 2007) aligned with the pragmatic worldview. The context of this research influenced the researcher's choice of an intervention designed to bring institutional change to family-school partnerships, specifically in relation to Black girls' identities as math learners. A pragmatic worldview allowed the researcher to use methods and frameworks best suited for the problem at hand. In this study, both qualitative and quantitative measures were used to provide a more complete understanding of the research problem (Creswell & Plano, 2007). The realities of the sample size and the research questions (above) lent themselves to an embedded design where qualitative data about the intervention process are embedded in the different, quantitative strands of data. The researcher used quantitative data including student grades, and Bandura's (1989) MSPSE (see Appendix E for the MSPSE for parental self-efficacy) to confirm or deny inductive findings from analysis of focus-group and other qualitative data. The mixed methods design ideally permitted an exploration of participants' experience, as well as the collection of generalizable data to support future interventions (Creswell, 2014).

Four guiding propositions. Leviton and Lipsey's (2007) four propositions guided a description of the research intervention process. These included (a) defining the problem, (b) examining critical inputs, (c) addressing how mediating interactions would support project success, and (d) clarifying specific treatment effects and side effects. First, Leviton and Lipsey proposed that the problem should be defined. Here, the problem is math underperformance by fourth-grade Black girls in an urban public school context. Variables that may affect math achievement for the target group were operationalized as parent self-efficacy with supporting their daughters as math learners and students' self-identification as math learners. Next, Leviton and Lipsey proposed an examination of the critical inputs that are most likely to produce, in this case, a homework intervention to increase parent self-efficacy, student math achievement, and subsequently student math identity. Here, the critical input was TIPS, an interactive homework intervention. An effective homework intervention required homework distribution that was consistent over the six-month's timeframe allotted. For successful implementation of the intervention, students and parents participated by (a) completing IRB permission, (b) completing pre and postintervention assessments, and (c) participating in biweekly homework and turning in homework on time.

The third proposition addressed how the interactions of the mediating variables within the various project parameters made the intervention successful. The research intervention is contextualized by project parameters including the sample size of approximately forty students. Though the sample size was small, it was large enough to explore the relationship between TIPS, families, and the school. Each student must have completed 12 homework assignments which might have led to 480 returned parent comments; however, not all students completed each homework, and not all parents left comments. Qualitative measures included the written portion of the Draw-A-Mathematician test, the focus group, a Survey of Students about TIPS homework, and Family Survey of TIPS activities. Quantitative measures, including student grades, the MSPSE (Bandura, 1989), and a Draw-A-Mathematician test (Chambers, 1983), added texture to the themes that emerge from the qualitative data. Creswell and Plano (2007) recommended using mixed-methods research when a single data source was insufficient. Here, mixed methods were used to allow a more accurate description of the family-school participation to emerge. The intervention was limited by the frequency and quality of family-child participation. When students took home the interactive homework, they had to teach that week's skill to a parent or family member and work with a family member to find connections between the math skill and everyday life. The parent then responded to a prompt in the Home-to-School connections section of the homework and signed the homework. Families were encouraged to choose a consistent homework partner to participate in the intervention. The researcher then collected participation data from the biweekly signatures and comments. If more than one family member participated, the parent participant did not receive the intended dosage. Because parents sometimes faced time limitations or other barriers, gaps may have occurred in the participation consistency of parents. Further, with no control to measure against, the research outcomes are not true indicators of how the intervention affected research variables.

Finally, Leviton and Lipsey (2007) recommended clarifying the specific "nature, range, and timing or various treatment effects and side effects" (p. 36) of the outputs. In this case, increased parent self-efficacy, student math achievement, and student math identity are desired outputs. If MSPSE scores for parents in the treatment group to increase at all, this would be a minimal output for parent self-efficacy. A maximal output might be an indication of a cognitive shift in how parents think about their math knowledge as a tool for their daughters' success. The cognitive shift might be represented (a) lexically as recorded on the postintervention questionnaire, (b) through at-home math activities as described in postintervention questionnaire, or (c) through descriptions of parent actions to support math learning outside of the TIPS intervention practice.

Minimal math outputs would show an increase in fourth-grade math grades and indicate that TIPS homework influenced student achievement. However, since many of the students at CPS— including most of the focus group participants— consistently scored the highest math grade, grade increase was not possible as a measure of minimal math outputs. Thus, an increased ability on the DAM test to describe math from a conceptual rather than simply a procedural perspective was added as an indicator of minimal math output for higher achieving students. Without a control group and with a sample size too small to successfully determine an effect size, embedding quantitative data comparing pre and postintervention math scores might add trustworthiness to the qualitative research (Nastasi & Schensul, 2005); an analysis of the math language for higher achievers would give a sense of whether higher achieving students are improving. Minimal math identity outputs would show an increase in how children conceptualize themselves as math learners as measured by the Draw-A-Mathematician test. Maximum math identity would present as a cognitive shift in how learners describe themselves as math learners including their present and future expected engagement in math related activities.

Logic model. Where the theory of treatment considers the big picture and how contextual elements affect the research intervention, the logic model (see Appendix F) focuses on the details of the program. Using the logic model as a guide helped to clarify the project goals (Leviton & Lipsey, 2007). The logic model, like the theory of treatment, describes a process where students, their parents, and teachers participate in biweekly, interactive TIPS homework. Participation in this process is expected to lead to increased parent self-efficacy with supporting their daughters as math learners, increased student math scores as indicated by students' grades, and subsequently to increased student math identity. Below a rationale for the process and outcome evaluations precede the instrumentation and methods that will be used in this intervention.

Process Evaluation Questions

1. How does the individual teachers' consistency with implementation affect the quality and quantity of family participation?
2. How does the frequency and quality of parent participation with TIPS homework influence the level of growth with parent self-efficacy, student math achievement, and student math identity?

Question 1. Successful implementation of this embedded exploratory design depended upon the fidelity with which the participating teacher introduced, distributed, collected, and reviewed the homework. The research design was conceptualized to support the teacher with doing these tasks in accordance with intervention protocols. Early in the intervention process, long before homework is distributed, the researcher met with both the intended control and treatment teachers to get buy in. The head of school in both cases encouraged teachers to participate, but also allowed teachers to make a decision about whether to participate. Though two schools ultimately did not participate, teachers from all three schools agreed to participate and were invested in the early process.

The researcher had met with one teacher several times, and had observed his classroom, and worked with him to align TIPS to his curriculum. The teacher was enthusiastic about the project, and his buy-in seemed genuine. However, the teacher was already busy with several projects and his work as a cheerleading coach. Getting responses from him about meeting times or other necessary parts of the process was difficult. Ultimately, he did not collect the consent forms needed to conduct research. Another school agreed to participate after the researcher met with the head of school and gave her and the teacher a White paper about the research intervention. That researcher tried to contact the teacher several times during the early planning stages, both independently of and through the head of school; however, the teacher did not respond, making it impossible to make plans.

The teacher who remained with the research—Ms. Vader communicated with me during this time to ask for clarification about protocols, and to share information about her classroom context and students. She noted that her strongest fourth-grade math students were Black girls and wanted to make sure that the TIPS homework would be challenging enough for them. Ms. Vader also wanted to make sure that the homework aligned with her curriculum, and that her students and families would see the value in participating in the research. To increase the chance that project implementation would have long-term success, the researcher helped Vader visualize how the theoretical framework aligned with logistical systems, processes, and school culture (Evans et al., 2012). Having clear, consistent protocols that did not make excessive demands on Ms. Vader's time was another way to ensure buy in. Vroom (2003) noticed that not engaging stakeholders was one factor in decisions unraveling. On the other hand, when stakeholders gave input into decision-making, Vroom found that 80% of decisions surveyed were successful. To sustain teacher participation at a high degree of fidelity, the researcher communicated with Ms. Vader throughout the research, and responded to her feedback about the process. Throughout the process, Ms. Vader distributed homework, and collected data with fidelity. Each group of TIPS assignments was rubber-banded and returned to the researcher with a completed protocol check-off list.

Question 2. Two procedural measures of fidelity that were required for intervention constructs (including parental self-efficacy, Black girls' math achievement, and Black girls' math identity) to have face validity included (a) the frequency of parent participation and (b) the quality of parent participation (O'Donnell, 2008). If parents did not participate in the interactive homework, it would not have been possible to evaluate how their participation moderates the relationship between different research constructs. Likewise, if the quality of parental participation was not consistent across families, research findings were less likely to be attributed to the intervention.

An indicator of parent participation included the number of homework assignments returned to school with a parent signature. The parent's signature was one characteristic of the TIPS process (see Epstein & Van Voorhis, 2001; Van Voorhis, 2011), and it was counted as a proxy for parent participation. Parents also gave feedback or comments about TIPS; these were collected by classroom teachers and given to the researcher as evidence that the parent had participated on some level. The researcher kept a record of parent frequency which was analyzed to learn more about the relationship between parent participation and research outcomes. Successful participation is a multi-faceted construct involving (a) teacher fidelity with implementation, (b) the student taking the homework home, (c) the family finding time and space to do complete the homework, and (d) the student returning the homework to the teacher on time (if homework is late, the homework review is likely to be less meaningful for the child). These steps had to have occurred for the researcher to affirm that the parent participated. If the child did not return the homework within the given time limits, parent participation was not affirmed even if the parent did indeed participate on the homework. A situation where parents participated but did not turn in homework was infrequent; had it not been, this unrecorded participation would have confounded research results. Comparing student reports with the homework that is returned will help teachers to identify and address situations where there is a gap. Maximum fidelity here meant that (a) parent and child interacted on all assignments, (b) the parent commented in the "Home-to-School" section and signed the homework, and (c) the child returned the completed homework to school on time. For minimum fidelity, we established that families would complete at least nine of the twelve assignments, or approximately 75%.

To determine the quality of parent engagement on homework, the researcher analyzed parent comments on homework which had been returned to school and collected by the teacher.

TIPS homework includes a place for parents to sign-off that they did participate in the homework. “Home-to-School” section where parents were encouraged to write observations, concerns, and comments about each homework assignment (See Appendix G). The number of parent signatures was counted, and other information gathered from this prompt was coded deductively for evidence that the parent (a) was physically present during part of the homework process, (b) provided additional explanations or demonstrations to help the child succeed, (c) supplied real-life connections to the homework, and (d) extended lesson by doing additional related activities at home. Any of these comments on “Home to School” were defined as high quality parent engagement. The Survey of Students about TIPS homework asked students who helped them on TIPS activities with possible answers being, (a) usually a parent, (b) a parent or someone else, (c) I do them myself, (d) I never do homework, and (e) other _________. These data gave an idea of general parent participant trends across the whole group. Maximum fidelity of parent engagement quality will be biweekly evidence of at least one indicator of participation beyond physically presence. Minimum fidelity of parent engagement was that the parent is physically present, meaning that they signed the TIPS homework, for 75% of the homework tasks. A parent could sign the homework without having participated; however, a parent might not sign the homework, an indication of an even lower level of participation. The Survey of Students about TIPS data was compared to the number of signatures to add trustworthiness to the study (see O’Donnell, 2008). By triangulating two perspectives related to the same data point the researcher hoped to increase confidence that the parent participation measure was accurate.

Fidelity of implementation. This intervention was in its effectiveness stage. TIPS has been used with favorable outcomes in several contexts over the last 15 years. TIPS was implemented in a fourth-grade classroom school as part of an intervention to increase math identity for Black girls, which indicated that one purpose of the evaluation was to “measure the ability of the program to produce the desired effect in actual use” (O’Donnell, 2008, p. 42).

Fidelity of implementation should also be high (O'Donnell, 2008). Fidelity here serves several purposes. Rossi, Lipsey, and Freeman (2004) wrote that program insiders are likely to think of the *true* program in its idealized form. Outsiders, by contrast, think of the program in terms of what they see happening. High fidelity aligns outsider and insider understanding of what the program represents. High fidelity also indicates high internal validity. Low fidelity indicates a gap between the idealized and actual intervention and indicates low internal validity. Even if teachers follow the implementation protocols faithfully, there are several confounding variables in this design. Individual teacher characteristics, current teacher-family relationships, and the classroom community dynamics are variables that are likely to influence student and parent participation.

High fidelity of implementation included both structural and procedural indicators (Dusenbury, Brannigan, Falco, & Hansen, 2003; O'Donnell, 2008). Structural fidelity means that participants do what is expected. Components were delivered as designed (dose) which meant that Vader gave all fourth-grade students homework every other week. Procedural indicators of high fidelity included the quality of homework delivery. High fidelity participant responsiveness meant that Vader completed and returned a protocol check-off sheet for each homework event. Low fidelity of implementation would have occurred had these indicators not been fulfilled. The more unfaithful indicators, the lower the fidelity of the project would have been.

A high-fidelity intervention made construct validity in the outcome more likely by increasing the likelihood that the intervention is responsible for any resulting effects. However, there was a possibility that there would have been no effects even had fidelity been high. Low fidelity would have made it difficult to attribute changes to the intervention (Nelson, Cordray, Hulleman, Darrow, & Sommer, 2012).

Indicators of fidelity of implementation. The indicators chosen for this assignment were (a) homework quality, (b) protocol check-off sheets for each homework event, (c) percentage of homework collected, and (d) quality of parent engagement on homework. Fidelity in each of these areas is needed to implement the project as is indicated by the logic model.

Homework quality. The homework acts as a place of connection between families, schools, and math content. Homework quality is essential to fidelity of implementation. Each fourth-grade student was given a biweekly, interactive homework following the TIPS model (Epstein & Van Voorhis, 2001). High-quality homework reinforced math skills indicated by the fourth-grade math curriculum and contained each component indicated in the TIPS model: (a) a letter to parents explaining the purpose of the task, (b) materials needed, (c) an interactive activity that included the student explaining the skill to the parent, (d) home-school communication with parent feedback or thoughts, and (e) parent signature (see Epstein, 2011).

Protocol check-off sheet. Studying the teacher's fidelity of implementation was especially important in an effectiveness study where the researcher hoped that the program, in this case TIPS, would produce an anticipated effect (O'Donnell, 2008). For high fidelity of implementation, the original plan included clear fidelity indicators to ensure that the teacher followed protocols faithfully. The measure of indicators here was a check-off sheet to be completed with each homework distribution event (see Appendix H). The check-off sheet required the teacher to check off each implementation indicator as it was completed. These indicators included (a) teach skill, (b) 5 minutes to introduce homework script following guidelines, (c) distribute homework, (d) collect homework after 1 week, (e) respond to parent feedback (treatment group only), (f) 5-min review of homework, and (g) submit homework to researcher. After checking off each of these indicators, Ms. Vader signed and dated the sheet. The measure was returned to the researcher with the homework. It is conceivable (but unlikely) that the teacher checked off elements without reading or completing them; the sheet did at least provide the teacher with a reminder which was intended to increase the probability of the high-fidelity implementation standards.

Homework completion. Fidelity of implementation required students to complete the homework. The tool that measured how much homework was returned was a simple spreadsheet. Students had two-week to return homework. The teacher indicated whether homework was on-time, late, or not returned on the spreadsheet. The higher the percentage of homework returned, the higher the fidelity of implementation with this indicator.

Parent engagement. Another indicator of fidelity here was the quality of parent engagement. The intervention is predicated on the idea that contextualizing math content within the overlapping spheres of the child's life will increase student math skills and math identity as well as parent self-efficacy with supporting their daughters as math learners. High fidelity parent engagement requires that treatment group parents interact with their children and the school on TIPS homework. The measure of this indicator of fidelity is the home to school communication sheet included in each TIPS homework assignment. A completed sheet indicates that parents have engaged with their child on the assignment. If students interact with a family member other than the participating parent to do the homework, the structural fidelity will be compromised.

Project differentiation. With all participating students receiving the treatment, there was no way to differentiate between a comparison and treatment group.

Outcome Evaluation

Evaluation Design

A single data source was insufficient for this project. An embedded exploratory model was chosen to allow qualitative data describing the intervention process to be supported by the quantitative data. This intervention specifically focused on gathering data to explore the relationship between a family-school partnership and the math identity of Black, female students. Math knowledge and skills alone may not be enough for some Black girls to feel a sense of belonging in the higher-level math classes that are often prerequisites for STEM careers. Research that stereotype threat can have a deleterious effect on learners' academic achievement

(Aronson et al., 1999; Beilock et al., 2007; Forbes & Leitner, 2014; Krendl et al., 2008; Larnell et al., 2014; Steele & Aronson, 1995) is an indication of the power that social identities have on behaviors. Though Steele and Aronson (1995) found that stereotype threat is more likely to affect those who already position themselves as math learners, there is evidence that having a strong math identity is a key predictor for math success (Chavous et al., 2008; Larnell, 2013; Phan, 2013; Tschannen-Moran et al., 2013). The underlying assumption of this research was that positioning math content learning within the mesosystem interactions between student, family, and school (Bronfenbrenner, 1977) would help students feel a sense of belonging in math learning communities. Further, embedding the problem of math underperformance of Black girls in a CRT framework acknowledges that interactions on the mesosystem level are influenced by racism. Thus, math underperformance is an indication of organizational racism, and not student ability.

This intervention focused on a family-school homework interaction. All fourth-grade students participated in the intervention, and data were disaggregated by race and gender. Over a six-month period, fourth-grade students at CPS received biweekly, TIPS homework (Epstein, 1995; Epstein & Van Voorhis, 2001; Van Voorhis, 2011). Using a pragmatic paradigm and a CRT framework allowed the researcher to use both quantitative and qualitative methods to explore how the family-school partnership affected the educational experience of some Black girls. Measures were given to students and their parents, before and after the intervention. Adding texture to the family-school engagement data were quantitative measures including the MSPSE for parent self-efficacy (Bandura, 1989), Draw-A-Mathematician for student math identity (Chambers, 1983), and student grades. Qualitative data included parent comments on the biweekly home to school section of the TIPS homework, the Family TIPS Survey (Epstein, 2011), the Student TIPS Survey, teacher observations of students' effort and confidence with math, and focus group conversations.

Ms. Vader's class, originally one of two treatment groups, became the focus of the study when the other treatment group stopped participation. Ideally, participation in the treatment group would lead to a statistically significant increase in parent self-efficacy, student achievement, and math identity that contradicts the null hypothesis. However, without a comparison group against which to measure the treatment group, this study will not be able to make statistical determinations about the intervention findings. Twelve homework assignments given to approximately 40 students, yielded approximately 480 pieces of data from the homework alone. For other measures, there will be 40 pieces of data.

A sense of what might happen without the treatment is typically demonstrated through a comparison group (Shadish, Cook, & Campbell, 2002). A relatively small sample size, by itself, made determining causal effect unlikely, the lack of a comparison group further diminished the credibility of any claim that any changes observed after the intervention are related to specific treatment variables (Creswell & Miller, 2000).

A comparison of triangulated data collected from the participants do not so much minimize the chance that changes related to maturation might be confused with treatment effect, as they give a more complete explanation for what occurred during the intervention (O'Donnell, 2008). Parents who participated in the intervention focus group were also given an opportunity to review the focus group data as one strategy for increasing validity in this study (Creswell & Plano, 2007; Nastasi & Schensul, 2005).

Method

Participants. The most important stakeholders for implementation was the teacher, Ms. Vader. Ms. Vader is a White woman in her late twenties with 12 years of teaching experience in the Urban District. She teaches math and science to several fourth-grade classes at CPS and is that school's Positive Behavioral Interventions and Supports lead. The fidelity of implementation depended on how faithfully she followed protocols to introduce, distribute, collect, and review the biweekly homework. Ms. Vader has a high interest in her students' math success and a position of moderate power in the intervention (Bryson, 2004). Her stake in implementing this intervention was as a cocollaborator who contributed expertise about students, and who gave the researcher formative feedback about the intervention.

The researcher was not directly involved in the research. As an observer, she collaborated with Ms. Vader to choose homework; introduced the project idea to stakeholders, kept track of timelines, collected, and analyzed data; and presented findings. Though finding statistical validity as established by psychometric instruments was not possible, the researcher tried to determine the credibility of the study through making sense of interpretations (Creswell & Miller, 2000). Feedback from biweekly homework, and postintervention surveys was one way to ensure that the study accurately describes the participants' experience.

Other participants included the students. Approximately 40 students from one school participated. Students represented diverse social identities including race, gender, and ethnicity. Parents also played a role. They completed pre and postintervention MSPSE tests, a TIPS family-school survey, and participated in the interactive homework. Four student-parent dyads attended the focus group.

Participant selection. The research was contextualized within one fourth-grade math class at CPS. While each fourth-grade student was expected to do TIPS homework as a classroom expectation, participation in the research was not required. Parents were informed about their rights to not participate and to remove their child from the research at any time. There was no penalty for not participating. All students' parents were invited to take pre and posttest measures including the MSPSE and a TIPS parent-school collaboration survey. Parents were also expected to interact with their child through the homework. Ms. Vader chose the families who composed the focus group through selective sampling (see Creswell & Miller, 2000).

Other key stakeholders. Where the teacher was critical to the implementation process, the stakeholder most necessary for evaluation was the principal at CPS. Her role in the evaluation process was to give the researcher access to school-wide testing data and to determine whether project outcomes merit the subsequent use of school resources. She also had a role in the implementation process as the authorizer of resources including meeting space, supplies, and possibly, teacher participation. She was a context setter with high-power and relatively low-interest in the research process (see Bryson, 2004). She was committed to addressing increased family-school engagement at the school as well as increased math achievement for her students, but did not engage, for the most part, in the intervention process. She did help the researcher reserve a room for the focus group, and she provided the researcher with student grades, as well as race and gender information. Engaging her as a context setter involved giving her a rationale of the planned intervention including a step-by-step plan of the process, time, and materials needed. Maintaining her interest during the implementation required a smooth implementation, and formative feedback that stakeholders, such as teachers, parents, and students, were satisfied with the process.

Instrumentation. Both quantitative and qualitative instruments were used for this mixed-methods study. Quantitative measures included the MSPSE for parents (Bandura, 2006), student grades, and the Draw-A-Mathematician test (Chambers, 1983). Qualitative measures included the TIPS “Home-to-School” data, the open-ended portion of the Draw-A-Mathematician test, and the postintervention survey. The teacher completed a two-characteristic pre and postintervention observation of student’s math effort and math confidence (see Appendix N). Bandura’s parent self-efficacy scale (Bandura, 2006) is briefly discussed below in terms of the construct that they are expected to measure as well as their validity and reliability. Please see Chapter 2 for a discussion of Chamber’s (1983) DAST, which influenced the Draw-A-Mathematician test used. Last, the qualitative instruments are briefly discussed.

Bandura's scale. Bandura (2006) wrote that global measures of self-efficacy without "relevance to the domain of functioning" (p. 307) did not have predictive value. He gave instructions for constructing a self-efficacy scale to address a specific domain. This research used a parental self-efficacy scale written by Bandura (1989). Bandura (2006) reinforced the content validity of his scale by choosing language that reinforces the self-efficacy construct, for example, he used "I can" statements of capability rather than "I will" statements of intention (p. 309). Bandura (2006) intended the scale to have construct and predictive validity; parents who score high on the parental scale should also demonstrate high self-efficacy with supporting their daughters as math learners. Williams and Coombs (1996) analyzed the reliability and validity of Bandura's MSPSE. Their study measured the self-efficacy of 500 White, middle-class junior high school and high school students. They found a high internal consistency with Cronbach's alpha reliability coefficient of 0.92 (Williams & Coombs, 1996, p. 5). They found that the MSPSE had both divergent and construct validity with nine distinct perceived self-efficacy scales. This scale has been modified and used extensively.

Qualitative methods. Qualitative data will be collected from the Home-to-School page on each interactive homework assignment. Qualitative data will also be collected from the student responses to the open-ended question on the Draw-A-Mathematician test and from a pre and postintervention survey. The TIPS family-school collaboration survey (Epstein, 2011) was another measure sent home to all fourth-grade parents.

Collaboration with teacher. The researcher and teacher prepared for the intervention by choosing TIPS homework to support the fourth-grade math curriculum from October through March. Another early task was communicating with the teacher and the principal of CPS to discuss the intervention plan's rationale, research design, and logistics. Teacher feedback was considered and applied when appropriate. As soon as IRB permission was awarded, the teacher sent an email written by the research inviting parents to participate. Ms. Vader talked to parents at an open house about the TIPS intervention and worked to get buy in from her students. She also conducted a two-characteristic observation of each student that captured her impression of the effort made by each child in math class, and their confidence as math learners (see Appendix I).

Before the first homework went home, preintervention assessments were given. The teacher gave students the Draw-A-Mathematician test (Chambers, 1983) in class. The MSPSE parent test (Bandura, 1989) and the parent and child IRB permission forms were available to parents through a cell-phone application. Homework went home every two-weeks. The teacher used a protocol checklist to ensure fidelity of implementation (see Appendix H). She taught the lessons that students needed to do the homework. Before giving students the homework to take home, the teacher spent 5 minutes discussing the process, reviewing skills if necessary, and reminding students of the due date. Students had 2 weeks to complete homework. The teacher collected homework and kept a record of who turned it in. As needed, she responded to parent comments in the home to school section. Teachers then spent 5 minutes reviewing homework with students. The teacher gave homework to the researcher who made a record of parent comments. Parent and teacher feedback were used when necessary to adjust the homework process. Students were given homework for 6 months or 12 doses. At the end of 6 months, the posttest measures, including were given. A focus group was conducted with four student-parent dyads (described below). Data were collected and analyzed. Findings were presented to stakeholders.

Procedure

While waiting to receive permission from the required IRB, the researcher prepared all necessary testing and homework materials. After gaining IRB permission, the researcher met with the teacher to get buy in for the intervention, and to discuss the implementation process and other relevant protocols. Next, fourth-grade parents were informed about the intervention through an email and through a teacher discussion with students. Some participating parents (n=12) completed a preintervention MSPSE (Bandura, 1989) made available online and by text. IRB forms for parents and students were linked to this electronically delivered test. All fourth-grade students took the Draw-A-Mathematician test and were given a letter grade based on performance each quarter of the school year.

Intervention. The first homework was sent home in November. Subsequent homework was sent home on a bi-weekly basis. Students had two-weeks to complete homework.

Postintervention. The final homework assignment went home in late May, before PARCC testing began. Students and parents took postintervention assessments. A focus group with four parent-child dyads was conducted by the researcher. The researcher analyzed data and shared findings with stakeholders.

Ms. Vader selected four Black girls and their parents to participate in a postintervention focus group. The girls and their parents met with the researcher in the teacher's lounge of CPS after school. The room contained a large, square table and enough chairs for all participants. There was also a refrigerator where the researcher kept seltzer water, chilled for the participants, and a side table where pizza, plates, and cups were placed for participants to share. Gift certificates were available for each participating family (a $10 gift certificate to an independent ice cream shop in Waterstown, and a $25 gift certificate to a local grocery store). All participant names are pseudonyms.

Participants

Valencia and Cardi. Valencia is a Black woman in her mid-thirties. She did not mention the type of work that she does but did share that she is pursuing a master's degree in a public policy field at Big University. Valencia's child, Cardi, like the other focus group children, is a fourth-grade girl. Valencia is raising Cardi and another daughter. Valencia contributed to the conversation more frequently than other adult participants. Using a transcription of the focus group conversation to measure the frequency of participants' speech, Valencia spoke 62 lines compared to 51 for Elmer, 40 for Francois, and 10 for MayBell. Cardi was relatively quiet during the group, speaking much less frequently than the other girls. The focus group transcription showed that Cardi spoke seven lines compared to 13 for Rainbow, 17 for Kitty, and 102 for Leila. Cardi turned in 83% of the homework, or ten out of twelve. Of these, seven were signed by Valencia. Cardi's grades over the course of the school year in order by quarter were: Passing, Satisfactory, Satisfactory, Good.

MayBell and Kitty. MayBell is a middle-aged White woman who works at Big University in an administrative role. Her daughter, Kitty, made an E for excellent each quarter this school year. Kitty turned in 94.6% of her homework, and MayBell signed each turned in piece of work. MayBell, and her husband adopted Kitty who is an only child.

François and Leila. Francois works at a national bakery chain where he is a manager. He is a Black man. He and his wife have one son as well as Leila. Leila, made all Es for excellent this year. She turned in 94.6% of the homework, or eleven out of twelve. Of these, eight were signed by a parent.

Elmer and Rainbow Unicorn. Rainbow Unicorn, a biracial child, has a White father, Elmer and a Black mother, both of whom work in academic fields. Elmer, a technology expert, participated in the focus group. Rainbow Unicorn maintained straight Es throughout the year and was the only member of the focus group cohort to be officially designated as gifted, though both Leila and Kitty participated in a gifted and advanced learning program (GAL). She turned in 83% of the homework, each assignment signed. Rainbow Unicorn is one of three siblings.

Focus Group Process

When participants entered the teachers' lounge which had been reserved for the intervention focus group, they were invited to find a seat around a large rectangular table. After participants and the researcher had introduced themselves to one another, each participant chose a pseudonym to be used to protect their privacy. Next the participants reviewed the protocols which included (a) one speaker at a time, (b) "sharing the air" or giving all participants an opportunity to speak, (c) listening to other speakers respectfully. The researcher put the cell phone used to record the conversation on the table and asked that whoever was speaking hold the phone. The researcher gave enough time for each focus group question to make sure that participants had substantial time to answer. After all questions had been answered, the researcher asked if there were any further comments before turning off the recorder. Before the participants left, the researcher gave each family gift cards as compensation for their participation. The files were transferred to a password-protected computer and deleted from the cell phone recording device.

Focus Group Questions

1. What were/are some of your favorite things about learning math?
2. What, if anything, makes it difficult for girls to learn math?
3. How about race or ethnicity. Do you think that these pose barriers to math learning?
4. Specifically thinking about math, what kinds of math activities do you do together at home? This could include conversations, activities like cooking, or standard math worksheets.
5. How confident are you (homework partner) about preparing your child for the kind of math that is used on PARCC and tests like that?
6. What strategies do you use when your child does not understand a math problem?
7. How confident are you (child) about taking a test like the PARCC?
8. What do you do (child) when you see a math problem that is confusing or difficult?

After the focus group, the researcher transcribed the conversation and sent the transcript to each of the adult participants for a member check. The document was locked and required a password to open. For the member check (see Cresswell & Maxwell, 2000), the researcher asked participants to make corrections, add comments, or to otherwise ensure that the transcribed record accurately represented the conversation. The researcher waited one week for responses (no one responded) before coding the data. The data was coded inductively into three themes, each with several subcodes (Cresswell & Plano, 2007; see Chapter 5). Qualitative data from other measures including the Family TIPS Survey, the Student TIPS Survey, and the open-ended responses for the Draw-A-Mathematician Test were included with the focus group transcript in the thematic analysis.

Timeline

The intervention occurred between November, 2018 and May, 2019. IRB permission from Big University and from the school district was secured before data collection began (see Appendix J for table of timeline).

Intervention

Data Collection

Data for all measures needs to be collected in a way that reflects participants' everyday life (Bergold & Thomas, 2012). As the research was contextualized in the overlapping spheres of school and family, data collection should not create undue stress on the family-school systems. Grades were chosen as a measure of within-school student math achievement because they are already used by CPS. The homework distribution process was made as simple as possible to fulfil the research objectives without burdening the teacher. To make taking assessments easier for parents, the MSPSE was distributed through a cell-phone application and linked to IRB permission. This method of delivery ensured that all parents had access. If parents did not have access to a cell phone, a cell phone or computers were available for parents.

All fourth-grade students were given pre and post intervention assessments including a Draw-A-Mathematician test. The teacher made pre and postintervention observations about students. Parents took pre and postintervention measures: (a) MSPSE (Bandura, 1989) to measure self-efficacy related to supporting daughters as math learners

Qualitative data was collected from the home to school connection section of the biweekly homework. Each participant in the sample of 36 students (forty distributed across two classes minus two students who did not turn in the IRB form, and two who left the school) was expected to complete 12 homework tasks with their parents. Best case scenario, this would have generated 480 pieces of homework which would have been triangulated with other sources of data including MSPSE and Draw-A-Mathematician data (see O'Donnell, 2008).

Data Analysis

The researcher predicted the independent variable, the TIPS intervention, would influence four dependent variables: (a) family-school relationship, (b) parent self-efficacy to support girls as math learners, (c) student math achievement, (d) and student math identity. To answer the intervention questions, quantitative and qualitative data were collected and analyzed separately. Results were then merged (see Cresswell & Plano, 2007). Triangulation of quantitative and qualitative data provided cross-verification of the data (O'Donnell, 2008). Quantitative data were analyzed descriptively. To test for assumptions that some expected findings were possible, paired *t*-tests were used for some research questions. Qualitative data were collected by deductively and inductively analyzing parent comments on homework, and open-ended Draw-A-Mathematician questions (Cresswell & Maxwell, 2000). The measure for parental self-efficacy (MSPSE) was not specifically written to measure parental self-efficacy with supporting daughters as math learners. The test was not modified; however, parents were asked to "think about supporting your daughter/son in math" before completing the assessment.

For the first intervention question, descriptive statistics were used to compare the relationship between parent participation and parental self-efficacy with supporting their children as math learners. The researcher shared observations based on data for the whole group, with a specific focus on the four parent-student dyads who exemplify the following grade trends: *decreasing*, *maintaining a low grade, maintaining the highest grade,* and *increasing*. In order, these students are Aiden, Susana, Leila, and Cardi. The researcher relied on qualitative data gathered from a focus group, and the open-ended sections of Surveys and the Draw-A-Mathematician test to learn more about the quality of parent participation for student exemplars and their parent partners

The second intervention question focused on participation in a home-based math intervention as an influence on how students saw themselves as math learners. The researcher used descriptive statistics to explore the relationship between participation on TIPS homework and student math identity. Next, the researcher used guidelines modified from Solomon's (2009) definition of math identity to identify evidence of student math identity in drawings and written descriptions for the Draw-A-Mathematician test. The math identity guidelines indicated (a) ways that the mathematician engaged in math (actions), (b) words used by the student to describe mathematicians (descriptions), and (c) math aspirations or indications of how math might be applied in the future.

The third research intervention question explored Black female students' descriptions of themselves as math learners and how those descriptions correspond with their math achievement scores. The researcher compared math identity and math achievement data for all student participants. Using a framework modified from Solomon's (2009) definition of math identity, qualitative data were used to further explore how a relationship between math identity and math achievement situates these girls as members of a community of math learners.

The original null hypothesis, before losing the comparison cohort, was that all student grades would increase the same amount either with or without the treatment. Students' sense of themselves as math learners would change the same amount with or without the treatment. Parent self-efficacy would increase the same amount with or without the treatment. The alternative hypothesis would have been that the treatment group would have had a statistically significant increase in parent self-efficacy, student math achievement, and student math identity. The effect size would have been determined using Cohen's d. An expected effect size for student achievement based on research using TIPS in other contexts has ranged from d=.23 to d=.49 which gives a small to medium effect size (Epstein & Van Voorhis, 2001; Suggate & Reese, 2012). However, as a pre/postembedded design, this intervention project is more useful for exploring the relationships between variables. Thus, the researcher will use the data gathered from this intervention to better understand the relationship between a home-based math intervention, and student math identity.

Qualitative measures include pre and postintervention TIPS family-school partnership survey, bi-weekly parent responses on the school to home communication connected to the homework, and a qualitative question added to the Draw-A-Mathematician test (How are you like this mathematician?). Data were coded deductively and inductively. Some predetermined variables were examined. Themes that emerge from a text analysis of each group's data were synchronized within the context of the problem-of-practice. Each month's data were analyzed individually and in relation to other data. The researcher sought a convergence of themes and ideas by triangulating qualitative and quantitative data. Data was shared with parent participants and participants were given an opportunity to express reservations, ask clarifying questions, or confirm findings (Cresswell & Plano, 2007).

Conclusion

The research design for this pragmatic, mixed methods intervention emerged from concerns expressed by parents at the needs' assessment focus group at PCM (Jeter, 2016). Focus group parents were frustrated by the lack of family-school connection related to curricular content. Within an educational context where homework was typically not given, some parents wanted homework (Jeter, 2016). Based on an analysis of research literature and parent feedback, a family-school homework intervention was chosen. Next, the worldview was determined-pragmatism- with an epistemological power to use the mixed methodology needed to obtain useful solutions that contextualize numeric measures in the participant's context. The choice of a pragmatic worldview also drove the perspective of the research design. For example, an axiological assumption grounded in pragmatic research is that the research takes both a subjective and an objective view (Creswell & Plano, 2007). This assumption predicated the implementation of a process where qualitative explorations are embedded in quantitative data.

Indicators that this research was successfully implemented included how faithfully the teacher followed the protocols for introducing, distributing, collecting, and reviewing homework. After triangulating quantitative and qualitative data, the researcher used it to negotiate a credible representation of the parents', students', and teachers' experiences in the family-school collaboration (see O'Donnell, 2008).

Chapter 5

Results and Discussion

The purpose of this dissertation research was to explore the relationship between math learning contextualized in a family-school homework partnership, parent self-efficacy with supporting their daughters as math learners, student sense of math identity, and student math achievement. Included in this chapter are brief descriptions of Waterstown, the neighborhood where CPS students live, and CPS. This chapter also shares background information about the intervention focus group participants, and process. Next, is a presentation of and discussion about the process evaluation questions, shared in Chapter 4, and the primary research questions, also introduced in Chapter 4.

Waterstown Neighborhood

This pre/postembedded exploratory research intervention was conducted at a public school, CPS in an urban city in a Mid-Atlantic state. Most of the descriptions below are based on personal observation, or conversations with neighborhood residents. CPS serves a formerly White working-class neighborhood that was once economically dependent on local mills, and factories. By the 1970s, the departure of these industries from the area caused an economic slump in the neighborhood and crime increased. In the 1990s, the gentrification that helped rebuild the neighborhood economically attracted artists and residents who are generally more socially and politically liberal than Waterstown's original inhabitants. Around the corner from the school are boutiques, an organic hair salon, antique stores, yoga studios, and other moderate to high-end establishments. Reminders of the old neighborhood remain and include the hardware store, a corner pizza shop, and a yearly festival dedicated to the colloquial language and customs used by inhabitants of the neighborhood, especially during the mid-20th century. Waterstown, once a rallying point for the city's Ku Klux Klan, still has a majority White and Protestant population. Most residents are homeowners, but around 20% live below the poverty level (Niche, 2019). The increases in housing prices that arrived with gentrification have pushed some of the original residents out and made it difficult for others to find suitable housing. Homeless people live in doorways on the main business street, and people play music or ask for money. Within walking distance from a methadone clinic, a steady presence of people with addiction issues travels the main street, often gathering at a centrally located convenience store (as told to the author by a resident). Watersford's main street is also heavily trafficked by visitors who come to eat, shop, or enjoy events: outdoor yoga classes, art shows, bocce games, or festivals. Off the main street in the residential section of Waterstown, residents live in an assortment of single-family dwellings, duplexes, and row houses. Gardens, little free libraries, artwork, and an abundance of Pride flags decorate the usually peaceful neighborhood which earned high ratings on Niche, a neighborhood webpage, for its cohesive and progressive community (Niche, 2019).

City Public School

CPS has 451 students ranging from prekindergarten to eighth grade. CPS is a neighborhood school that offers a gifted program, and honors courses, and it is a site for English as a second language students. Of the 25 teachers, 20% have taught for ten or more years in City Schools, and 44%, including Ms. Vader, have taught from 6 to 10 years in the system. Unlike PMC where the needs assessment occurred, CPS has consistently met city mandates to increase the percentage of students from all demographics who pass PARCC each year. Whereas a racial achievement gap biased toward White students persists at PMC, CPS scores show that Black students have stronger scores. In 2018, 56.4% of Black students at CPS met or exceeded expectations, as compared to 48.3% of White students. However, CPS does have a significant socioeconomic achievement gap that has not been satisfactorily addressed.

Research Questions

RQ1. In what ways does participation in a home-based math intervention influence parental self-efficacy to support their Black girl's math learning?

RQ2. In what ways does participation in a home-based math intervention influence students' math identity?

RQ3. Over the course of the intervention, how do Black female students' descriptions of themselves as math learners converge with their academic scores?

The research was guided by these questions and this chapter will examine results for each question, as well as a discussion about research fidelity, and further steps indicated by the research. Before looking at outcome data, this chapter will review the fidelity of the participating teacher's participation, and the frequency and quality of parent participation.

Process Evaluation Questions

1. How does the individual teachers' consistency with implementation affect the quality and quantity of family participation?
2. How does the frequency and quality of parent participation with TIPS homework influence the level of growth with parent self-efficacy, student math achievement, and student math identity?

Process Evaluation Question 1

Implementing the homework with fidelity was a necessary element to ensuring that the intervention was delivered effectively. Structural components included those indicators that measured that homework was delivered as it was designed; procedural indicators included the quality of homework delivery. The indicators chosen were (a) homework quality, (b) protocol check-off sheets for each homework event, (c) percentage of homework collected, and (d) quality of parent engagement on homework. Fidelity in each of these areas was needed to implement the project as is indicated by the logic model.

Homework quality. Ms. Vader and the researcher worked together to align the homework with the curriculum. We agreed that homework would be delivered every two weeks unless school was interrupted by a vacation, or other extended break (snow days, testing, etc.).

Ms. Vader wrote the due date for homework assignment on each biweekly protocol sheet. She completed 100% of the protocol sheets –one was required for each homework assignment- (See Appendix H). On 100% of the protocol sheets, Vader indicated that she had followed the procedure with fidelity with one exception. She did not remind students to work with their family partner, which might have influenced the rate of parent-child participation. Ms. Vader was organized. Each packet of homework, data, or consent form was returned on time, neatly clipped together. She knew which skills her students needed to practice, and she helped the researcher determine which TIPS homework to choose. Had Ms. Vader not been so organized and invested in making the intervention work, it was unlikely that students would have participated at such a high rate, or that they would have been so invested. She tried to distribute homework every 2 weeks as planned, but she postponed homework when students were out for snow days or during testing.

Percentage of homework completion. Out of 45 students, 40 returned their IRB permission. Of these 40, four left the school during the intervention, leaving 36 participating student-parent dyads. For in class tasks like the Draw-A-Mathematician (Chambers, 1983), and the student survey (Epstein, Simon, & Salinas, 1997), Ms. Vader was able to get 100% participation. The rate of completion was somewhat lower for tasks or assessments completed outside of the classroom. She collected 367 out of a possible 432 TIPS homework assignments, an overall individual homework completion rate of 84.9% with a distribution range from 33 to 100%. The most frequent individual rate of student homework completion was 91.6%, or 11 out of 12 homework tasks. Students who participated in the focus group averaged a somewhat higher percentage of completed homework: 89.5%., and the Black girls who participated turned in 90.5% of the homework required. This is compared to the mean individual homework completion rates for White girls (68.7%), Black boys (75.8%), and White boys (89%). These percentages indicate completed homework not necessarily signed homework. The percentage of homework completion does meet the minimum fidelity standard of 75%. Ms. Vader's consistency was likely to be one factor that led to this level of homework completion.

Process Evaluation Question 2

The percentage of parents who participated on the homework was gathered from the TIPS homework, and from the parent TIPS survey. At the focus group, participating students and parents had positive feelings about both Ms. Vader and what they called *the yellow homework* (the homework was always delivered on yellow paper). According to the Family TIPS Survey, 100% of families liked the homework, and approximately 90% of the students did. Comments about TIPS gathered from the Family TIPS survey included the following:

- I highly recommend our school keep using TIPS.
- Continue to give TIPS to the students!
- This was great! Loved the communication it added about what was going on in school.

Ms. Vader returned 100% of protocol check-off sheets, which showed she had established TIPS as part of her classroom routine. Participation was measured in several ways. First, a parent's signature on the biweekly TIPS homework was counted as evidence of their participation. Signing homework did not necessarily mean that engagement happened. However, a parent signature did indicate that parents who signed made an effort beyond the efforts made by parents who did not sign. Second, data were collected from the student survey and used to gather an overall impression of who partnered with students to do homework. One measure of fidelity in this intervention was the quality of parent participation which was defined as the frequency with which the parent partner participated. If the parent partner did not participate or changed over the course of the intervention, the quality of delivery had lower fidelity. As mentioned above, signatures on TIPS homework were not a valid indicator of whether parents actually worked with their children on the assignment or whether they supported their daughters as math learners. Perhaps parents participated but did not sign the form. Other parents may have signed without participating, or students could have forged their parents' signatures. Though an imperfect measure, the signature was at least an efficient way to gather an impression of who participated.

Out of an anticipated 432 pieces of homework (12 pieces for 36 students), 367 were returned to the teacher. Had all 367 pieces of homework been signed by a parent partner, that would have given 84.9% parent participation. Overall, 291 parents signed, accounting for 79.2% of the homework submitted and giving an overall parent participation of 67.3%. Aggregated by race and gender, 88% of parents of Black girl; moreover, 59.2% of parents of Black boys, 93% of parents of White girls, and 77.3% of parents of White boys signed homework.

Parent Participation and the Family Survey

All participating children completed the student survey in school. Twenty-five parent-child dyads completed the Family Survey on TIPS at home. Responses on the student survey indicated that 93.02% of the students worked with a parent partner on the TIPS activities. On another item, 83.72% of students agreed either a little or a lot that "At home, a family partner can help me with homework." The 10.7% discrepancy between these two items' scores may indicate an inconsistency in rate that parents participate with their children. Taking the lower rate of 83.72%, enough parents met the minimum indicator for consistent parent participation where (a) students indicate that parents helped with homework *most of the time*, (b) student and parent complete at least 75%, or nine out of 12, of the homework assignments. The maximum indicator would include participation above 75% and evidence that parents engaged in math activities at home.

Other Measures of Parent Participation

Other evidence shows robust parent participation even where the parent did not consistently sign the TIPS homework. An example of such participation emerged from the focus group. The 12% of unsigned TIPS homework turned in by Black girls were turned in by three girls, two of whom participated with their parents in the focus group Cardi turned in 58% of the possible signed homework, and 83% of the homework overall. Leila turned in 66% of the possible signed homework, and 91.6% of the homework overall. The other two girls who participated in the focus group (Rainbow Unicorn and Kitty), both turned in 11 out of a possible 12 signed homework assignments. All four girls either improved or maintained at the highest-grade level over the course of the year. Though Cardi and Leila turned in a lower percentage of signed homework, their parents helped with the TIPS homework at least some of the time.

Data from the focus group showed that both girls' parents have mixed levels of confidence with supporting their daughters as math learners at school. Cardi's mother, Valencia said, "I mean, I can do my best to teach her what she needs to know at that level and at home can focus on the day to day lessons of class. I just know I can help her when she gets the work." Leila's father, Francois demonstrated self-efficacy with helping his daughter succeed by reaching out to teachers for support as needed:

> The teachers here are very informed, very open. You can go up to them and say, hey, Leila has this particular math equation. I don't know how to explain it. If you come to school with it and need to talk to them about it, they will. If you come after school, they will.

By participating in conversations focused on specific topics with Ms. Vader and other CPS teachers, Francois could increase the chance that the time spent in school was directly beneficial to his daughter's success. When faced with helping her child succeed with math work that she knows little about, Valencia was less confident.

> As far as the question goes. Do I feel prepared? Prepared means before they know. That means, I would have to know before they know. And if I don't know what she's gonna learn, then of course, I'm not going to know. So, that's why I say, no, I do not feel

prepared. If she comes home with a piece of paper never having learned any of it, and I was supposed to teach her what they are expecting, I'm not confident that I can do that. When you say, do you think that you are confident to help her be prepared, that's a dead no. Because, I have no idea of what they expect.

Francois said that his confidence level "is kind of iffy," but he does know how to get help from teachers at school or online.

Though Francois and Valencia signed a relatively low number of TIPS homework compared to the other focus group members, they demonstrated that they participate in their daughters' education through showing up at school to ask questions, by attending the focus group, and finding other ways to help their daughters succeed in school. A parent's signature on homework is the indicator of parent participation used here but is by no means the only indicator. This observation reflects Epstein's (2004) framework of six types of family-school engagement (see Appendix M). Parents in the focus group demonstrated different types of family-school engagement, but even within the fourth level (learning at home), parental strategies varied from helping with (and signing) homework, to starting a business (Francois & Leila), cooking (MayBell & Kitty), having math conversations (Elmer & Rainbow Unicorn), and modeling life-long learning by going to graduate school (Valencia).

Parent Participation and Positive Growth Outcomes

How do the frequency and quality of parent participation with TIPS homework influence the level of growth with parent self-efficacy, student math achievement, and student math identity? Without a comparison group, no data are available to show whether the TIPS intervention made a difference with any of these variables. However, an exploration of the available data– parent surveys, homework participation, comments on homework, and student grades, can examine the relationships between these variables among the participants.

Though, no correlation can be made with such limited data and with no comparison group, the researcher was able to compare each subgroup's rate of improvement in several categories over the year with their parental participation rates. Ms. Vader gave students math grades every quarter. The grading scale ranged from E for excellent to U for unsatisfactory. Within that range, students could score a G for good, an S for satisfactory, a P for passing, or an N for needs improvement. Looking at the grades over the four quarters of the 2018-19 school year, twelve of the participating students improved academically. Two students' grades got worse. The other students maintained consistent scores, either earning the same score for each quarter, or starting and ending with the same score. The average math identity score for the students with the top six levels of parent participation (92%, 83%, 75%, 67%, 58%, 50%) was 1.6; The average math identity score for the students with the bottom six levels (42%, 33%, 25%, 17%, 8%, 0%) of parent participation was slightly lower at 1.57. The mean grade trend for the top level is 1.67. The mean grade trend for the lower level is 1.17. The researcher also compared mean math identity and grade trends between students when parents participated at least 75% (the minimum level of fidelity), and students whose parents did not participate at the minimum fidelity level. The students whose parents participated at 75% or higher (n=15) had a mean math identity score of 1.5, and a mean grade trend of 1.55. Compare this to the students (n=20) who participated less than 75% and students' mean math identity score was 1.62, and their mean grade trend is 1.37. These data show that the frequency of parent participation did influence students' grades, and to a lesser degree, students' math identity.

The researcher could not use the MSPSE to measure changes in parent self-efficacy with supporting their children as math learners because a low number of parents take the survey, and because with anonymous MSPSE results, it is unclear whether those who took the survey took it both pre and postintervention. Some qualitative data was available from surveys and the focus group. Parents made eight positive responses about their experience with TIPS on the Family

TIPS survey; however, none indicated that their self-efficacy with supporting their children as math learners grew during the TIPS intervention. All four focus group parents said that TIPS helped them with supporting their daughter as a math learner; two mentioned that the TIPS intervention changed how they worked with their daughters. No parents made negative comments about TIPS (though two said that they would like more help from the school with TIPS). Based on the qualitative data, there is a sense that participating in TIPS homework has been a positive experience for parents and has influenced the self-efficacy of some of those parents.

Table 4

Parent Participation and Four Research Variables

Parent participation	*N*	Math identity	Confidence	Work effort	Grade trends
0	1	2	3	2	2
.08	1	1	2.5	1.5	0
.17	2	1.75	3.75	2.5	1
.25	3	1	3.75	2.25	2
.33	1	1.67	1.5	2	1
.42	2	2	2	1.5	1
.5	2	2	2	1.5	2
.58	2	2	2.5	1.5	2
.67	6	1.17	1.67	1.42	1.33
.75	2	1	2	1.5	1.5
.83	5	1.8	1.3	1.1	1.4
.92	8	1.63	1.81	1.31	1.75

Note. All students (*n* = 35).

Quantitative Process

The percentage of homework completion meets the minimum fidelity standard of 75%. Ms. Vader’s consistency is likely to be one factor that led to this level of homework completion. Therefore, the answer to the first process evaluation question was that the teachers' consistency with implementation does affect the quality and quantity of family participation on TIPS. The answer to the second question is that the frequency and quality of parent participation with TIPS is positively aligned with student grade trends, and to a lesser degree, the development of students' math identity. TIPS seems to have had a positive influence on some parent's self-efficacy, and it was an overall positive experience for parents and children.

In this section, the process and analysis of quantitative data are described. The quantitative data discussed included (a) TIPS participation data, (b) teacher protocol sheets, (c) Draw-A-Mathematician racial and gender identity scores, (d) Family TIPS Survey, (e) Student TIPS Survey, (f) MSPSE results, (g) teacher observations, and (h) student grades. The qualitative data described in the commentary below include (a) open-ended responses on the Family TIPS Survey, (b) open-ended responses on the Student TIPS survey, (c) Draw-A-Mathematician, and (d) focus group.

Quantitative data collected by the researcher included (a) TIPS (Epstein, 1995; Epstein & Van Voorhis, 2001; Van Voorhis, 2011) participation data, (b) teacher protocol sheets, (c) teacher observations of student math confidence and effort, (d) Draw-A-Mathematician racial and gender identity scores (Chambers, 1983), (e) Family TIPS Survey (Epstein, 2011), (f) Student TIPS survey (Epstein et al., 1997), (g) student grades, and (h) MSPSE results (Bandura, 1989).

Participation Data

Ms. Vader collected the TIPS homework from students every 2 weeks. After reviewing homework with students, she gave the researcher the homework along with a completed protocol sheet. The researcher kept a record of how many homework assignments were turned in for each child and also how many homework assignments signed by a parent were turned in.

Teacher protocol checkoff sheet. Every 2 weeks, Ms. Vader filled out a protocol sheet. She wrote the date, the number of homework collected, and checked off each step of the homework distribution and collection process as she completed it. The steps included (a) teach skill needed to complete homework, (b) introduce homework to the students, (c) remind students to work with their homework partner, (d) review homework requirements, (e) remind students of homework due date, (f) count completed homework, (g) review completed homework, (h) collect homework, and (i) respond to parent comments.

Teacher observations. Ms. Vader collected observations of two student behaviors related to math: confidence and work effort. The teacher used a Likert scale to record her impression of students in these areas. The teacher gave a score ranging from one to four with lower scores indicating a higher confidence level or work effort, and lower scores indicating a lower confidence level or work ethic (see Appendix I for a sample of the scale). For both the work effort and confidence scores, the lower the numeric score, the stronger the student's skill in that particular area is. For the grade trend and math identity scores, the higher the numeric score, the higher the student's skill. The teacher collected observations of these behaviors in the beginning and at the end of the school year.

Draw-A-Mathematician

This measure was modelled after Chamber's (1983) DAST, which examined student stereotypes about scientists. In DAST, researchers evaluate how many of seven stereotypical indicators are present in student drawings. The indicators are lab coat, glasses, facial hair, research related symbols (test tube, Bunsen burner, etc.), symbols of knowledge (atomic models, scientific formula), products of science (technology) and statements that are relevant to science (Chambers, 1983). In the improvised DAM test, the researcher looked for evidence of students' stereotypes about mathematicians based on race and gender, only two indicators. The Draw-A-Mathematician assessment (Chambers, 1983) gave a sense of the students' stereotypes about mathematicians, including their perceptions of who can be a mathematician based on gendered and racial identities. Ms. Vader gave each student a paper and asked them to draw a mathematician on the front, and to describe their mathematician on the back. Students were given two points if both their gender and race were represented in the DAM drawing or writing, one point if only. one of these identities was represented in their answer, and zero if the answer did not show any of their gender or racial identities. The researcher compared students from four subgroups: Black girls, Black boys, White girls, White boys. Math identity was measured as the number of a student's racial or gender characteristics were represented in their drawing of a mathematician on the DAM test. The math identity score looked at both the BOY and the EOY average number of the student's racial or gender identity characteristics included in their drawing of a mathematician for the DAM test.

Family Teachers Involve Parents in Schoolwork (TIPS) Survey

This survey (e.g., Epstein, 2011) was distributed to participating families after the intervention had concluded. Ms. Vader sent the surveys home with students directing them to ask their parent each of the survey questions, interview style. The survey asked how much families liked TIPS, how often families worked together on homework, and their opinions on different TIPS activities. The survey also asked whether families wanted the school to have TIPS homework the following year. Six of the questions are presented in either yes/no or in a Likert scale format. The seventh and final question asks parents to share their comments and suggestions.

Parent participation was determined in part by parents' response to an item on the Family TIPS Survey: About how often does your child ask you to do work on TIPS activities? Possible responses to that question were: *once a week, once every other week, once a month, once in a while*, and *never*. None of these sources alone were likely to give an infallible estimation of whether parents participated, so the researcher included data strands from different perspectives to gain perhaps a more accurate picture of what happened (Creswell, 2014; O'Donnell, 2008; Yin, 2014).

Next, data about parental self-efficacy with supporting their children as math learners were gathered from focus group responses when applicable, and from parents' answers to five Likert Scale items on the Family Survey on TIPS activities. The parent was asked to rate learning activities done at home—which of the activities did you like to do most?—with either (a) *like a lot*, (b) *like a little*, and (c) *I dislike*. The five activities included (a) listen to my child read the homework, (b) assist with a math problem, (c) talk with my child about when I was their age, (d) show me something he/she learned, (e) interview me for my ideas about things, and (f) discuss ideas about math. On the Family survey, parents marked whether they *agreed a lot, agreed a little,* or *disagreed* that "the activities take too much of my time." The researcher also looked at parents' responses to the prompt: I need more information from the school to do TIPS with my child. Parents answered this item with either (a) *I agree a lot*, (b) *I agree a little*, or (c) *I disagree.* Each of these Likert scale responses was assigned a number with larger numbers indicating a higher level of enjoyment or confidence with TIPS activities. Lower numbers indicated a lower level of enjoyment or confidence with doing TIPS activities. Each parent-student dyad's responses were averaged to get a score.

Student Teachers Involve Parents in Schoolwork (TIPS) Survey

Ms. Vader gave her students the Student TIPS Survey (Epstein et al., 1997) after the intervention had been completed. Students took this ten-question survey anonymously in class, using a paper copy. Besides having 10 questions that encourage students to share about their experience with TIPS homework, students are also encouraged to share comments or suggestions at the end. Most questions follow a Likert scale model with participants indicating whether they *agree a lot, agree a little, disagree a little*, or d*isagree a lot* with a statement about TIPS. One yes/no question asks whether students like TIPS. Students are also asked who helps them with TIPS.

Multidimensional Scale of Perceived Self-Efficacy Survey

Ms. Vader gave parents a link to an online version of the MSPSE survey (Bandura, 1989). Parents took this survey anonymously. This measure was offered both before and after the intervention. Parents were asked to think about the survey items in relation to supporting their children's as math learners while taking the survey. MSPSE measures self-efficacy across different domains: (a) efficacy to influence school related performance, (b) efficacy to influence leisure time, (c) efficacy in setting limits, monitoring activities, and influencing peer affiliations, (d) efficacy to exercise control over high-risk behaviors, (e) efficacy to influence the school system, (f) efficacy to enlist community resources for school development, (g) efficacy to influence school resources, (h) efficacy to control distressing rumination , and resiliency of efficacy (Bandura, 1989). Questions are domain specific and are calibrated to learn more about the participant's self-efficacy within that domain. The number of questions in each domain varies from two (efficacy to influence school resources) to ten (efficacy to enlist community resources for school development). Participants respond to each question by choosing an answer from a five item Likert scale. They are asked to choose one of the following responses: *nothing, very little, some influence, quite a bit*, or *a great deal*. Questions across the domains take a similar format, for example: *How much can you do to prevent your children from getting in with the wrong crowd of friends* (efficacy to influence leisure time). Or, *how well can you stop yourself from worrying about things* (efficacy to control distressing rumination) (Bandura, 1989). MSPSE data were analyzed by Survey Monkey. The researcher looked at the mean scores for questions in each self-efficacy domain. Two domains, efficacy with controlling distressing ruminations and resiliency of efficacy, were combined into one group of *self-regulation*. The researcher grouped items by their Likert scale score into two groups: the positive scale that included three items (*a great deal, quite a bit, some influence)* and the negative scale that included the last two items *(very little, nothing*). The first three items and the negative scale included the last two items.

Student grades. The school principal gave the researcher access to students' grades, race, gender, and other identifying information. Math grades were collected over four quarters by Ms. Vader based on daily student homework, class participation, and unit tests. They follow a six-level scale where *U* for unsatisfactory is the lowest grade, followed by *N* for needs improvement, *P* for passing, *S* for satisfactory, and *G* for good, and *E* for excellent. To determine a grade trend based on each student's year-long math performance, the researcher looked for evidence that the grade had decreased, maintained at a low level, maintained at the highest level, or increased over the course of the year. Decreasing grades were given a score of 0, maintaining grades were given the score of 1, and increasing grades were given the score of 2. Additionally, students who maintained grades at the highest level (E) were scored at 2.

Quantitative Findings

Participation Data

Thirty-six parent-child dyads participated in TIPS homework. Out of an anticipated 432 pieces of homework (12 pieces for 36 students), 367 were returned to the teacher with a distribution range was 33 to 100%. The most frequent individual rate of student homework completion was 91.6%, or 11 out of 12 homework tasks. Focus group participants completed 89.5% of their homework, and the overall Black girls who participated turned in 90.5% of the required homework. Mean individual homework completion rates for White girls was 68.7%, Black boys completed 75.8%, and White boys turned in 89% of the TIPS homework. These percentages indicated completed homework, not necessarily signed homework.

Had all 367 pieces of homework been signed by a parent partner, that would have given 84.9% parent participation. Overall, 291 parents signed, accounting for 79.2% of the homework submitted and giving an overall parent participation of 67.3%. Aggregated by race and gender, 88% of parents of Black girl. 59.2% of parents of Black boys, 93% of parents of White girls, and 77.3% of parents of White boys signed homework.

Each of the exemplar students completed more than 75% of the homework assignments. Cardi, Aiden, and Susana completed ten out of 12, or 83% of the homework, while Leila completed eleven, or 91.6%. Susana had 83% of homework signed, and Leila's parents signed 67%. Aiden's parents signed 58% of the homework and Cardi's parents signed 42%. Focus group members Cardi and Rainbow Unicorn completed 83% of the TIPS homework. Kitty and Leila completed 91.6% of the homework. Using the parent's signature as proxy for parent participation, Cardi turned in 42% signed homework. Leila turned in 67%, Rainbow Unicorn and Kitty turned in 83% and 91.6%, respectively.

Table 5

Student Exemplars Participation and Math Identity Indicators

	Parent percentage	Actions	Actions	Descriptions	Descriptions	Aspirations	Aspirations
Aiden (decreasing grades)	67	3	0	1	0	1	0
Susana (maintained low grades)	83	2	1	2	0	0	0
Leila (maintained highest grades)	67	1	8	4	2	0	4
Cardi (grades increased)	58	0	2	7	0	0	1

Teacher protocol checkoff sheets. Ms. Vader completed 100% of the protocol sheets and returned one with each group of TIPS homework. The only item that she did not check off was *remind student to work with their homework partner if possible*. This item was not checked off on any of the 12 check-off sheets.

Teacher observations. Girls' effort in math class increased from 1.93 to 1.57 from BOY to EOY. There is also a slight improvement in confidence level from 2.2 to 2.0. For males, all variables decreased: (a) effort decreased from 1.57 to 1.90, (b) confidence decreased from 2.07 to 2.20. For Black students, effort increased slightly from 1.75 to 1.71, and confidence decreased from 2.19 to 2.25. For White students, effort increased from 1.81 to 1.63 and confidence increased from 2.24 to 2.00. The effort of the Black girls in the class increased from 1.89 to 1.56; their confidence with learning math increased from 2.20 to 1.67. Within the group of Black girls, the focus group participants' effort score remained at 1.25, while their confidence improved slightly from a mean of 2.0 to a mean of 1.75. Overall, each group increased in the two variables measured from BOY to EOY (effort and confidence). The exception was the male subgroup where the mean score in each of these measures decreased.

The researcher conducted a series of paired *t*-tests to test an assumption that the outcome is predictable, and that the difference between the BOY and the EOY mean score for math confidence and effort did not occur by chance. A paired *t*-test was conducted to learn if a prediction could be made for the change in student math identity from the BOY to EOY. The paired t-test found that the BOY to EOY mean difference for the teacher observation of work effort showed significance with a p value of 0.031 when $p < 0.05$. The BOY to EOY mean difference for the teacher observation of student confidence with math learning was not significant with a p value of 0.1604 where $p < .05$. The BOY to EOY mean difference for the teacher observation of student math identity was not significant with a p value of 0.729 when $p < .05$.

Table 6

Paired t-*Test Scores for Three Variables*

	M	*SD*	Std. Error M	95% Confidence Interval of Difference Lower	Upper	*t*	df	Sig. (2 tailed)
Effort with math BOY-EOY	0.235	0.606	0.104	0.024	0.447	2.264	33	0.300
Confidence with math BOY-EOY	0.176	0.716	0.123	-0.074	0.426	1.436	33	0.729
Math identity BOY-EOY	-0.059	0.983	0.169	-0.402	-0.402	-0.349	33	0.729

Note. If p < 0.05, the scores for effort are significant with a p value of 0.0303; the scores for confidence and math identity are not significant with respective p values of 0.160 and 0.729.

Draw-A-Mathematician Test

In the BOY tests, 18 males, and 16 females drew a mathematician with the same gender identity as them. These totals shifted to 14 males, and 20 females in the EOY assessment. The racial identity statistics changed over the course of the year for Black, but not White students. Twenty-eight White students drew a White mathematician both for the BOY and EOY test. No White student drew a mathematician of another race. Black students drew five Black mathematicians for the BOY and 11 for the EOY test. This group of 37 students included nine Black girls, 11 White girls, seven Black boys, and nine White boys. Girls math identity increased over the course of the intervention from 1.30 to 1.74. Boys' math identity decreased from 1.24 to 1.0. Black students' mean math identity increased from 1.39 to 2.00 and White students' math identity also increased from 1.63 to 2.00. Black girls' math identity increased from 1.0 to 1.6 over the course of the year. The math identity score for girls in the focus group increased from 0.75 to 1.75. The student exemplars' math identity scores were 2, 0, 1, and 1 for Aiden, Susana, Leila, and Cardi. Their EOY scores were 1, 0, 1, and 2.

Table 7

Draw-A-Mathematician Results

Identity group	Identities shared BOY	Identities shared EOY
Black girls (*n* = 9)	Racial: 3	Racial: 7
	Gender: 6	Gender: 8
White girls (*n* = 11)	Racial: 10	Racial: 8
	Gender: 6	Gender: 5
Black boys (*n* = 7)	Racial: 2	Racial: 4
	Gender: 8	Gender: 8
White boys (*n* = 9)	Racial: 7	Racial: 4
	Gender: 8	Gender: 8

Family Teachers Involve Parents in Schoolwork (TIPS) Survey

Twenty-five parent-child dyads turned in the family TIPS survey. Two surveys were not used because the students did not attend CPS for the duration of the TIPS intervention. Twenty-three families reported that their children asked for help with TIPS homework at least every other week. Twelve of these parents said that their children asked for help every week, more frequently than would be needed to complete the biweekly interactive homework. The remaining two students asked for TIPS homework support from their parents *once in a while*.

The researcher noticed that the distribution of these data was skewed toward students who had turned in from 83% to 91.6% of their TIPS homework; out of 23 responses, 15 came from this group of students. Next, the students who said they asked their parent to help with TIPS homework *once in a while* turned in signed homework either 83% or 75% of the time indicating a mismatch between the number of signatures on homework and their response on the Family survey. Six students who turned in less than 75% of the 12 possible signed homework wrote on the Family TIPS survey that they worked on TIPS activities with a parent either weekly or biweekly. The mean parent-child home activity score for all students who were high-maintainers or whose grade increased was 2.73, compared to a mean score of 2.62 for students who maintained a low score, and 1.88 for students whose scores decreased.

Survey responses follow. Every family responded that they use TIPS to do math homework. Seventy-five percent of participants liked TIPS *a lot* and 25% liked TIPS *a little*. One hundred percent of respondents would like the school to use TIPS again next year and think that TIPS is a good idea. For the question *I like working on the activities with my child*, 87.50 *agreed a lot* while 12.50 *agreed a little.* Twenty-five percent of parents a*greed a little*, that TIPS took too much time, compared to the 37.5% who *disagreed a little,* and 37.5% who *disagreed a lot.* TIPS helped 87.5% of the parents to learn more about what their child is doing in class; 12.5% slightly disagreed with this statement. Twenty-five percent of the parents needed more information from school to do TIPS compared to 75% who did not. Most parents, 87.50%, said that they want their child to go to college; 12.5% disagree with that a lot. All parents like to hear what their child is doing in school, and monitor their child's schoolwork closely. Asked whether they like to (a) hear their child read their homework, (b) assist their child with a math problem, or (c) watch the child show something they have learned, 87.50 parents liked these activities a lot compared to 12.5% who do not like them. Twenty-five percent of parents do not like to talk to their child about math or about being their child's age, two activities that 75% of the parents say they like. The ratio between parents who do and do not like for their child to interview them about things is 62.5: 37.5.

Table 8

Home Participation for Students Representing Different Grade Trends

Student Name	Grade Trend	Overall Completion	Number of Parent Signatures	Parent-Child Work Together (FTS)	Parent-Child TIPS: Home Math Activities (FTS)
Aiden	Regress-EGGG	83%	58%	Weekly	2.25
Susana	Low maintenance PPPP	83%	83%	Weekly	2.50
Leila	High maintenance EEEE	91.6%	67%	Weekly	3.00
Cardi	Improve	83%	42%	Bi-weekly	2.88

The mean parent-child home activity scores were, for Kitty, Cardi, and Leila's respectively, 2.5, 2.88, and 3.0, all scores indicating that parents and students enjoyed doing most of the TIPS activities (Rainbow Unicorn and her parent partner did not complete this task). The mean parent-child home activity scores for Aiden and Susana were 2.25 and 2.50, respectively. Looking at the activities that exemplar parents did at home to support math, Aiden's parent liked to do all but two of the activities with Aiden *a lot*. Two activities that Aiden's parents marked as *I do not like* were (a) talking with my child about when I was their age, and (b) having my child show me something he/she learned. Aiden's parents also indicated that they needed more information from school to do TIPS. Susana's parents liked to do all of the activities *a lot* but they thought that the activities took too much of their time. Additionally, Susana's parents said that they needed more information from the school to do TIPS. Cardi's mother liked having her daughter read homework to her *a little* but liked the other activities *a lot*. Cardi's mother *agreed a little* that the TIPS activities took too much of her time. Leila's father liked all activities *a lot*. The overall group trend (n = 25) for students who returned the Family TIPS Survey reflects the results from the exemplar group. The mean parent-child home activity score for all students who maintained the highest level of grades or whose grades increased is 2.73, compared to a mean score of 2.62 for all students who maintained a low grade, and 1.88 for students whose grades decreased.

Student Teachers Involve Parents in Schoolwork (TIPS) Survey

Responses on the student survey indicated that 93.02% of the students worked with a parent partner on the TIPS activities. 83.72% of students agreed either a little or a lot that "At home, a family partner can help me with homework." Though 40.91% of students indicated that they dislike TIPS, 90.7% of students want the school to have TIPS next year. A total of 12.73% agreed a lot, or a little that TIPS took too much time. Approximately half of the students preferred TIPS to the usual homework; 13.64% of students agreed a little that TIPS was too difficult. The rest either disagreed a little or a lot with that statement. When asked if their family partner liked TIPS, 27.27% agreed a lot, 45.45% agreed a little, 20.45% disagreed a little, and 6.82 disagreed a lot. Eighty-one percent of the respondents liked to have their parent partner listen to them read the problems; 72.73% liked to have their parent partner talk about when they were the students' age; 88.64% liked to show their parents what they learned; 79.54% liked to share ideas with their parent partner; and 50% like to talk about what they learned at school at home.

Multidimensional Scale of Perceived Self-Efficacy

With efficacy to influence school related performance, 31.26% of the participants felt that they had some influence in the domain, 27.03% with quite a bit, and 28.24% a great deal. They were confident in their ability to influence whether students value school, work hard at homework, stay out of trouble, and get good grades. Parents felt that they had at least some influence with making sure that their children associate with friends who are good for them, instilling values in children, and getting them to complete tasks at home. With efficacy to influence leisure time, 19.45% of parents felt that they had some influence, 47.22% had quite a bit, and 33.33% had a great deal. In the third category, efficacy in setting limits, monitoring activities, and influencing peer affiliations, one question garnered a negative response: *How much can you do to work with other parents in your neighborhood to keep it safe for your children*: 25% responded very little, and 8.33% responded a great deal. Overall, 26.85% had a great deal of confidence about their influence, 41.67% had quite a bit, 26.85% had some influence, and 3.7% had very little influence. For questions about efficacy to exercise control over high-risk behaviors the responses were evenly distributed between the three positive response options. There were no negative responses.

For efficacy to influence the school system, 9.26% of parents said that they had quite a bit of influence compared to 40.74% with some, 37.96% with very little, and 12.04% with none. Sixty-seven percent of the parents said they could influence teachers' expectations of their children. responses being positive. Asked about making the school a better place for children to learn, influencing social activities at school, and making other parents feel welcome, 58.33% felt they had influence, while 41.67% did not. Half of the parents believed that they could make the school a better place. Only 41.67% believed they could influence the curriculum used by the school; 58.33% responding negatively to this prompt. Thirty-three percent of the parents believed that they have influence over what is taught to their children or which books their child uses in school.

Looking at efficacy to enlist community resources for school development, 1.67% chose *a great dea*l, and 1.67% *quite a bit*. Approximately 60.83% of parents either had little or no self-efficacy in this area. For efficacy with getting resources for their school, 66.66% of parents were not confident that they could help get educational equipment, materials, public funding for special programs, or other resources for the school. Eighty-three percent did not have confidence that they could influence the size of classes. There were no negative responses for questions specific to efficacy to control distressing ruminations.

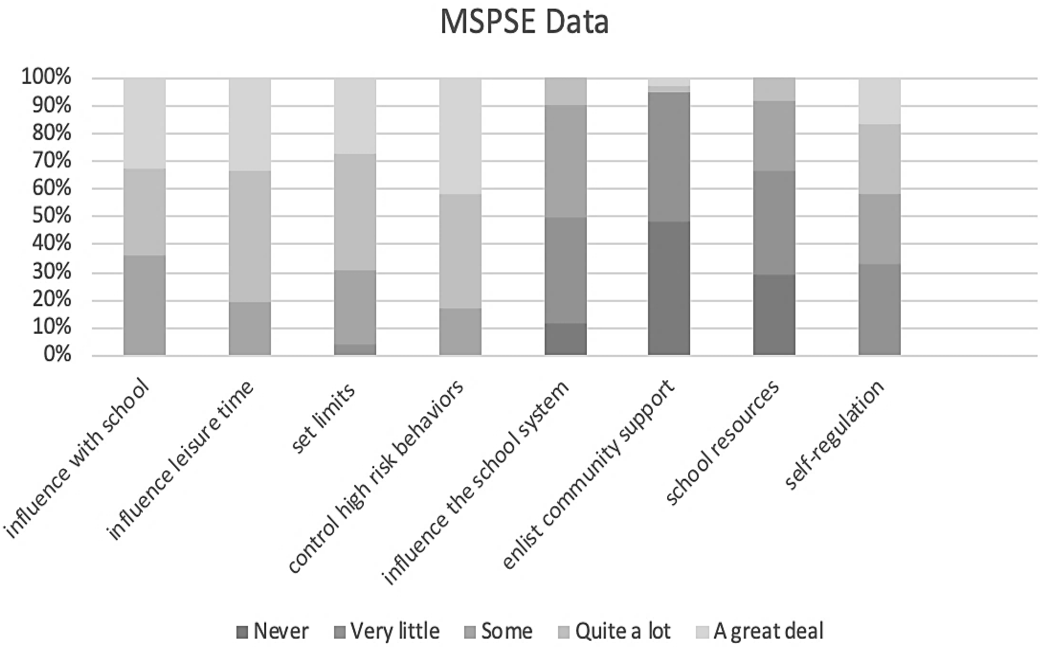

Figure 3. Select multidimensional scale of perceived self-efficacy data.

Student grades. Twelve of the participating students improved academically. Two students' grades decreased. The other students maintained their score. The mean grade trend for females was 1.74. For males, the mean grade trend was 1.38. For Black students, the grade trend was 1.65. For White students, the grade trend was 1.64. Aggregating the data by race and gender, 60% of the Black girls improved at least one letter grade, compared to 18% of the White girls, 44% of the Black boys, and 42% of the White boys. Using the data to measure how many students either grew or maintained an E, the highest grade, the data looks slightly different 90% of the Black girls either maintained an E or increased their grade over the year compared to 44% of the Black boys, 55% of the White girls, and 50% of the White boys. All focus group members either maintained a grade at the highest level (E), or increased their grade. Sometimes the researcher considered the experience of a group of student exemplars. These students represented four grade-trends: regressing, maintaining at a low-level, maintaining at the highest level, and improving. Aiden is the student exemplar for a regressing grade trend. His math grade regressed from E to G over the course of the school year. Susana is the student exemplar for maintaining at a low level. She maintained a P for passing over the course of the school year. Leila is the example of a highest-level maintainer as she maintained an E average throughout the four quarters of the school year. Cardi is the exemplar for improvement; her grade in math climbed from P to S to G, an improvement of two letter grades.

Table 9

Focus Group Parent Participation and Grades

Student	Grades	Grade trend	Overall homework	Parent signature
Cardi	P, S, S, G	2	83%	42%
Kitty	E, E, E, E	2	92%	92%
Leila	E, E, E, E	2	92%	67%
Rainbow	E, E, E, E	2	83%	83%

Note. Grade trends = 0 represents a decreasing grade tend across the school year; 1 represents a stable grade trend across the school years; and 2 represents an increasing grade trend or that the student scored the highest score, E, across the year.

Qualitative Process

Qualitative data collected by the researcher included (a) Draw-A-Mathematician responses, (b) open-ended responses from surveys and TIPS homework, and (c) focus group transcripts.

Draw-A-Mathematician Essays

Pre and postintervention, Ms. Vader invited students to respond to a prompt to draw a mathematician with a drawing and a written description. The researcher scored pre and postintervention drawings and comments from the Draw-A-Mathematician test (Chambers, 1983), and triangulated these data with data from across the school year (O’Donnell, 2008). This test was used to learn more about students’ developing math identity.

Markers of developing math identity were taken from Solomon's (2009) definition which includes (a) student beliefs about themselves as a math learner, (b) the student's engagement in math learning, (c) their perception about how other teachers and students think of them as a math learner, and (d) their math self-narrative and aspirations (Solomon, 2009). This definition was adapted to create math identity guidelines through which to analyze the DAM test. The modified guidelines were used to identify and categorize the indicators of math identity present in the students BOY and EOY DAM test. A modification was needed because the DAM prompt did not require learners to discuss their own experience with math. Instead, students wrote about an idealized mathematician. Some students did draw themselves as the mathematician; however, such responses to the prompt were atypical. The modified guidelines used by the researcher looked for the following elements in each child's DAM drawing and writing: (a) ways that the mathematician engaged in math, (b) descriptive words used by the student to describe mathematicians, (c) self-narrative or indications of the ways that math might be applied in the future.

The researcher compared the number of indicators in each category from the beginning to the end of the intervention. For (a), she counted every action as one point, so "my mathematician loves and does math" was given a point for *love,* and another for *does*. For (b), each unique descriptive word was given a point. For (c), every personal aspiration mentioned by the student (e.g. I want to be a scientist), was given a point. Every mention of a way to apply math in the future was given a point. The data were divided into four groups by parent participation: (a) 83% to 100% participation, (b) 58% to 82%, (c) 33% to 57% and (d) 32% and below. Because the sample size for each group differed (respectively, the sample sizes were 14, nine, four, and five), the researcher found a per individual average for each group. Finally, she made a note of any trends that emerged from this analysis of data.

Table 10

Mean Math Identity Scores by Participation Percentage

Participation percentage	Math identity BOY	Math identity EOY	*N*
91.6	1.5	1.5	9
83	1.0	1.4	5
75	2.0	2.0	2
67	1.7	1.3	6
58	2.0	1.0	2
50	1.0	2.0	1
42	1.0	2.0	3
33	1.0	2.0	1
25	1.5	1.5	3
17	2.0	2.0	2
8	1.5	1.5	1
0	N/A	2.0	1

Open-Ended Responses From Surveys and Homework

Responses from open-ended items on the Student and Family TIPS surveys were cleaned. These responses were coded with other qualitative data. The researcher followed process suggestions by Creswell and Miller (2000).

Focus Group

Four parent-student dyads comprised the focus group. The focus group conversation was recorded by cell phone, and then transcribed by the researcher. The first analysis of the focus group transcripts was both inductive and deductive. The researcher originally looked for key codes including parent self-efficacy, child self-efficacy, gender focus, racial identity, family-school, TIPS, home math activities, and parent-child relationship. math identity but added codes as they emerged. Some codes that emerged from the process included conceptual learning, procedural learning, self-efficacy actions, self-efficacy statements, future math applications, and math aspirations. This initial coding process helped the researcher discern the information delivered through the focus group process (Saldaña, 2013). The researcher predicated her choice of themes on this early analysis. From the three overarching themes several codes emerged. The researcher relied on the theoretical propositions framing the research study to determine the themes according to Yin's (2014) process:

- Theme 1: Family-school partnerships focused on math can help support mathematical self-efficacy for parents and their children.
- Theme 2: TIPS an interactive family-school homework provides a structure for parents to engage in a variety of activities that can support their daughter's math identity development and possible future school and workforce STEM aspirations.
- Theme 3: A strong math identity may help deepen learners' enculturation into the community of mathematical knowledge, practice, and belief.

Codes for the first theme are shown in the Table 11. They are (a) child self-efficacy (CSE), children's self-efficacy with math learning; (b) parent self-efficacy (PSE), parents' self-efficacy with supporting their children as math learners; (c) math at home (MAH), math activities that take place at home; (d) home to school communication (HSC); and (e) old vs. new math (OVM), pedagogical strategies from the past compared to the present. Codes for the second theme are (a) TIPS; (b) math in the future (MIF), which indicates opportunities to apply math in the future; (c) gender focus (GF), a focus on gender identity and math learning; and (d) family race related dynamic (RRD), factors that explain how Black parents support their children as math learners. The researcher used guidelines modified from Solomon's (2009) definition of math identity as a guidance. The codes that emerged from Theme 3 included CSE, MAH, and MIF. Subcodes emerged deductively from these codes. For example, MAH generated two subcodes: procedural (PK) and conceptual knowledge (CK).

Each theme corresponds to a different research question. The quantitative data support the qualitative data gathered from the focus group, DAM, and open-ended survey questions. Data are mixed sequentially (Creswell & Plano, 2007). The researcher analyzed the qualitative data set to determine which utterances or written phrases fit the codes supporting a specific theme.

Then, the researcher looked at how quantitative data contributed to the story told by the qualitative data and how both sets of data supported the given theme and answered the research question (Creswell & Plano, 2007).

Qualitative Findings

Draw-A-Mathematician. From BOY to EOY, the number of math actions described by the students decreased from 40 to 36. However, when the researcher removed actions that were vague or indicated no real math related action (she loves math; he does math were the two most frequent), there are 17 remaining math actions in the BOY and 22 in the EOY. More specific examples of math tasks included: (a) explain a process; (b) make a mistake, fix it, and try it again; (c) studies trajectory; and (d) trying to find the meaning for pi. The number of math descriptions decreased by more than half from 48 in the BOY to 16 in the EOY. Finally, EOY students mentioned 26 ways that they could apply math in the future, seven of which involved teaching; BOY students mentioned only 10, six of which involved teaching. From BOY to EOY, the number of descriptive words that students used to describe math decreased. However, the number of math actions and the number of future applications for math increased.

That students moved from describing mathematicians (smart, kind, helpful were common descriptors used) to defining mathematicians' jobs as evidence of math identity development. Looking at the scores for students who had 83% to 100% of their TIPS signed by a parent, scores in two of the categories declined. Students in this group described fewer specific math behaviors (a decline from 1.40 per individual to 0.86) and they used fewer words to describe mathematicians (a decline from 1.40 to 0.43). However, the number of aspirations or applications for math mentioned did increase from 0.14 per individual to 0.71. The students who turned in 58% to 82% of the homework increased their mentions of math activities from 1.1 to 1.6. Their use of descriptive language to describe mathematicians decreased from 1.2 incidents per person to 0.78. The number of math aspirations or applications mentioned by this group increased from 0.67 to 1.1.

The third group, those who turned in from 33% to 57% of the signed homework, increased in two categories. They increased the number of math behaviors mentioned from 1.25 per person to 1.5. They increased the number of math aspirations or applications that they mentioned from 0.5 to 0.75. Their number of descriptions of mathematicians decreased from two per person on the BOY to zero on the EOY. Finally, students under 32% decreased the numbers of math actions mentioned from 0.8 to 0.2. They decreased the number of descriptors for mathematicians from 2.0 to 0.6. However, like the other three groups, the fourth group increased the number of math aspirations and applications mentioned grew from 0.0 to 0.4.

Focus group. Focus group findings led to three themes. These are discussed in the following subsections.

Theme 1. Focus group parents spent approximately 6.2% of their conversation expressing high self-efficacy with supporting their daughters as math learners, while 8.5% of the conversation expressed low self-efficacy. These percentages are based on the number of words that fit the researcher's criteria for high or low self-efficacy out of the total relevant words spoken at the focus group (excluding within group pleasantries that were not connected to the main conversation). Within the PSE code, subcodes emerged: negative self-talk about supporting their daughters as math learners and worries or concerns about supporting daughters as math learners. Examples of negative self-talk included MayBell's response to whether parents felt confident about helping their daughters succeed at high stakes tests, "I'm becoming less confident as it gets harder." While parents generally expressed high confidence with supporting their daughters with specific math tasks, they were less confident about helping their daughters to succeed within their school. Areas of worry or concern according to the focus group data included (a) preparing for possible curriculum changes at the school level (HSC, OVN), (b) understanding school expectations now compared to when parents went to school (OVN, PK, CK), and (c) understanding teacher expectations for how work should be done (HSC, OVN). These focus group responses aligned with MSPSE data ($n = 12$) where parents demonstrated higher perceived self-efficacy in domains where they interacted with their children at home, and lower self-efficacy in domains where they interacted with teachers, community, or school to support their children. The researcher does not know whether any of the four focus group parents took the MSPSE (see Table 11 for codes for Theme 1).

Table 11

Theme 1 Codes

Theme	Code	Description	Exemplar Statement
Family-school partnerships focused on math can help support mathematical self-efficacy for parents and their children.			
	CSE	Children's self-efficacy with math learning	I feel a lot more confident, because my parents are able to help me with it. I feel like I'm able to explain how it is (FG, Leila).
	PSE	Parental self-efficacy with supporting their children as math learners.	I just use humor, cause she already knows it, she just needs, I don't know, what's the word, she just needs encouragement (FG, Valencia).
	MAH	Math at home: math related activities that take place at home	At home, I do a lot of cooking, and when it comes to measuring, I also need to use fractions and knowing that was our next curriculum, it really helped me, and then I could easily do it without having to think about it (FG, Kitty).
	HSC	Home to school communication, especially related to math learning.	If you come after school, they will (answer questions about schoolwork). Because the teachers want them to know (FG, François).
	OVN	Old vs. New Math: Compares pedagogical math Strategies from past and present.	I struggle with knowing what the expectation from the school is versus how I remember —I age myself—doing it forty years ago. Thirty years ago. I mean, things were very different (FG, Elmer).

Theme 2. Each focus group parent expressed worry about being able to support their daughter as a math learner (PSE). Beyond expressions of low self-efficacy, parents employed a range of strategies to support math learning at home. Parents were aware of their daughters' developmental needs and worked to support their children's physical needs and goals (PSE, MAH). Parents communicated with the school to do TIPS homework, but also to get help (François), and to find learning strategies to help a child (Valencia; TIPS, MAH, HSC). Parents participated in TIPS and other home math activities (TIPS, MAH). Potential barriers to home math engagement: "parents may "brush off homework—Not because they didn't want the kids to do it, but because they were embarrassed because they didn't understand it" (RRD, MAH, PSE). "Having way too much stuff happening outside of school and also having a lot of drama" (CSE; Cardi, FG) is another barrier. Additionally, students or parents may lack self-efficacy about their ability to meet school standards for work (CSE, PSE, OVN, MAH). Support for student math identity: All students in the focus group said TIPS had improved the way that they feel about themselves as math learners (TIPS, MAH, HSC, CSE). Focus group members talked about future aspirations. Seventy-five percent of the girls mentioned becoming a math teacher. Only two girls aspired to do something other than teaching. Leila wants to code, finish college by age 18, get a doctorate, be a "dancer, rapper, boxing, crazy basketball playing machine" in addition to becoming a teacher. Cardi wants to work at Starbucks (MIF, CSE).

Adding to the focus group data with comments from DAM, the students with the lower grade trends made fewer overall comments that expressed a sense of being a member of a math community. The lower-grade trend students each made five statements that indicated math identity. Leila made 19 statements, and Cardi made ten. The number of comments that Aiden and Susana made decreased from BOY to EOY in the math actions category. Aiden made fewer comments about math applications and aspirations from BOY to EOY; Susana made a consistent zero comments across the intervention. The number of comments that Cardi and Leila made increased in both categories (see Table 12 for codes for Theme 2).

Table 12

Theme 2 Codes

Theme	Code	Description	Exemplar statement
TIPS an interactive family-school homework provides a structure for parents to engage in a variety of activities that can support their child's math identity development and possible school and workforce STEM aspirations.			
	TIPS	TIPS feedback	Loved the communication it added about what was going on in school (FTS). It's pretty easy and I get to spend time with my dad and I like it a lot (FTS).
	MIF	Math in the Future: shows opportunities to apply math in the future	There are too few role models for these young women…. the only thing that they are thinking of right now is teaching, and there is so much more out there (FG, Elmer). If it was shown to them more often that this is the kind of math you would use as a doctor, this is the kind of math you would use if you were a…. (FG, Valencia)
	GF	Gender Focus: A focus on doing math related to gender	Math anxiety in women, girls, and I guess just being aware of the fact that one should be anxious… (FG, MayBell).
	RRD	Family Race-Related Dynamic: Factors that explain how Black parents support children as math learners	So, a minority who did not graduate from high school cause it was good enough to know how to count money, and then they dropped out to get jobs, cause that was what was necessary, now those parents aren't able to teach their children those high level math applications. (FG, Valencia).

Theme 3. The codes that support theme three are CSE, MAH, GF, MIF. Two subcodes that emerged from MAH are PROC (procedural knowledge) and CON (conceptual knowledge). Under the CSE code, students made more comments that reflected high self-efficacy than low (15.4% compared to 2.9%). Several of these high self-efficacy (CSE) statements also showed

math identity. "Like instead of just knowing the answer, like, we have a different way of doing stuff which explains it a bit more (Leila, FG). Leila was the only focus group child to express frustration with doing math, and she immediately moved the conversation into the strategies that she applied to move beyond frustration. Valencia shared examples of Cardi demonstrating low math identity: "If she doesn't get it immediately the first time, she says, I'm done, I don't want to do it" (CSE, MAH).

The students said that girls had specific barriers to math learning expressed by Kitty, "Too much drama, caught up in relationships...and stuff, and it's kind of a lot." The adult participants agreed that the girls need better math role models. MayBell expressed a concern about girls having anxiety about doing math. The only other comment made related to girls doing math was Valencia's comment that girls are natural problem solvers, "so doing math is not the hard part, it's showing the work that is the hard part" (GF, OVN). Concerns expressed by the group about race and math learning described larger social issues that may affect parents of Black children including the lack of opportunity to acquire math skills or experiences with the type of math required by schools (RRD).

One parent described TIPS as a "bit of involvement that we don't usually have." Parents and students described many activities completed at home. Subcodes that emerged from MAH were CON and PROC. The researcher found nine examples of conceptual knowledge building, and 11 of procedural knowledge building. Examples of parents supporting the development of procedural knowledge included double check and triple check answers, helping students learn steps to solving multi-step problems. Examples of parents supporting the development of conceptual knowledge include using context clues, figuring things out, connecting math learning to everyday experience, putting things together (models, experiments), using math language that supports conceptual development talking them through frustration, or modeling problem solving; see Table 13 for codes for Theme 3).

Table 13

Theme 3 Codes

Theme	Code	Description	Exemplar statement
A strong math identity may help deepen learners' enculturation into the community of mathematical knowledge, practice, and belief.			
	CSE	Child's self-efficacy. With math learning.	To me, being a mathematician means that you work hard, and even when you get the problems wrong you fix it (DAM, Leila).
	MIF	Math in the Future: shows opportunities to apply math in the future	I just think it's pretty evident that there are too few role models for these young women and for everyone in general, but for scientists, finding different ways to do things, the only thing that they are thinking of right now is teaching, and there is so much more out there, every one of us uses math in our life every day, and some of us use it regularly,
	MAH	Math at home: math related activities that take place at home	She just wanted to get it done and get it out of the way which I think comes from the —-you said there aren't any role models for them, but I think it's not understanding the life application of math (FG, Valencia)

Summary of Research Question 1 Findings

The researcher considered whether participation in a home-based math intervention, TIPS, influenced parents' self-efficacy to support their children's math learning. The researcher shared observations based on data for the whole group, with a specific focus on the four parent-student dyads who exemplify the following grade trends: *decreasing, maintaining a low grade, maintaining the highest grade*, and *increasing*. In order, these students included Aiden, Susana, Leila, and Cardi. The researcher relied on qualitative data gathered from a focus group, and the open-ended sections of surveys and the Draw-A-Mathematician test to learn more about the quality of parent participation for student exemplars and their parent partners.

Exemplar Students' Parents Participation and Self-Efficacy

As seen by each student's mean score for home-based math activities, there is a positive relationship between the number of TIPS activities that parents "like a lot," their ability to do TIPS homework with their child without extra support from the school, and students' grades. These quantitative data did not suggest a relationship between the parent participation and parent self-efficacy with supporting their children as math learners. However, focusing on the student exemplars and triangulating qualitative data with the quantitative findings (O'Donnell, 2008), the researcher gained a richer understanding of the relationship between parent participation and parent self-efficacy.

Overarching Theme

One theme that emerged from the qualitative data was that family-school partnerships focused on math can help support mathematical self-efficacy for parents and their children (see Table 14). Parents spoke of having low confidence with supporting math learning, and no parent explicitly expressed confidence in this area (FG). However, parents demonstrated that beyond verbal expressions of low self-efficacy, they employed a range of strategies to support math learning at home that encompassed at least four of Epstein's (2004) six types of family involvement (See Appendix M). At level one, parents were aware of their daughters' developmental needs and worked to support their children's physical needs and goals. At Epstein's (2004) second level, parents communicated with the school to do TIPS homework, but also to get help (François), and to find learning strategies (Valencia). All parents participated in volunteering (third level) throughout the year. The fourth level, learning at home included participation in TIPS. The quality of parent participation influenced each parent's belief that the intervention influenced their self-efficacy. For example, Aiden and Susana's parents relatively low enthusiasm about doing TIPS activities, may have contributed to their low self-efficacy with doing TIPS (FTS). Leila and Cardi's parents had a high interest in doing the TIPS activities; they also self-reported high self-efficacy about doing TIPS, and said that the intervention had helped them develop new skills to support their children (FTS). A brief case study looks at Valencia's participation in the research intervention.

Valencia

A closer look at the parent participation indicates that though Cardi's mother, Valencia, did make several statements indicating low self-efficacy with supporting her daughter as a math learner (PSE), most of the low confidence is focused on the idea of having to "teach what they want" (OVN). Valencia did not express low self-efficacy with her own ability to do math, or with her ability to "teach her (Cardi) what she needs to know" (PSE, MAH). Valencia spoke confidently about the strategies that she used to encourage Cardi stay on task including humor. Valencia expressed frustration that Cardi "gets the answer but she doesn't show it the way they want her to show it" (OVN, PK). Despite having signed only 42% of the homework, Valencia had several strategies for supporting Cardi as a math learner. Valencia often takes a procedural approach, expressing frustration with helping her daughter explain how she got specific answers. Still, Valencia's participation included encouragement, consistent check-ins, figuring out what is required, and motivating Cardi. Whether these rich expressions of parental participation contributed toward Cardi's increased grades in school is not clear. However, there is evidence that participating in TIPS has increased the way that Valencia supports her daughter as a math learner. She realized from participating in TIPS that Cardi needed more math support, more check-ins. Asked what she had changed since participating in the intervention and Valencia said that she had realized that showing students the practical applications for math would motivate them to learn. In the case of Cardi and her mother, parent participation in TIPS interactive homework did influence Valencia to have higher self-efficacy with supporting her daughter as a math learner.

Table 14

Home Math Activities With Focus Group Members

Type of activity	Elmer	Valencia	François	MayBell
Homework	Helped with homework (P, C)	Checked child's homework more often (P)	Help with TIPS (P, C)	
	Got daughter to double and triple check work (P)			
Beyond homework	Taught child about algebra (C)	Encouraged child.	Get child to read problem out loud (C)	Set up problems similar in structure to frustrating problems (C)
	Conversations about math (C)		Worked with child to start a business (C) Sent child to digital class (C) Looks for online math opportunities (P, C)	Cooks with daughter (P, C)

Note. P = Procedural knowledge; C= Conceptual knowledge

Summary Response

Does parent participation in a home-based interactive homework influence parents' self-efficacy to support their children as math learners? When quantitative and qualitative data were integrated, the researcher was better able to see a connection between the parents' support for their daughters and the development of self-efficacy. Parent involvement with TIPS influenced some parents to change the ways that they support their daughters as math learners, an increase in self-efficacy in that domain.

Summary of Research Question 2 Findings

The second research question focused on participation in a home-based math intervention as an influence on how students saw themselves as math learners. A relationship between parent-student participation on TIPS interactive homework and student math identity (DAM) were compared using descriptive statistics. Next, the researcher embedded the qualitative data from DAM in these findings (Creswell, 2014). Guidelines modified from Solomon's (2012) definition of math identity was used to find markers of math identity in DAM drawings and written descriptions. The math identity guidelines were used to find the following elements in each child's DAM drawing and writing: (a) ways that the mathematician engaged in math (actions), (b) words used by the student to describe mathematicians (descriptions), and (c) math aspirations or indications of how math might be applied in the future.

Student Exemplars: Home-Based Math and Math Identity

Theme 2 considers TIPS as it provides a structure for parents to engage in a variety of activities that can support children's math identity development and possibly their future school and workforce STEM aspirations. Using quantitative data alone, the researcher found a somewhat inconsistent relationship between participation and math identity. For the most part, an increase in parent participation indicated an increase in mean math identity; however, students with the highest level of signed homework (83% to 100%) had the second lowest mean math identity scores. To explore the relationship between home-based math and student math. identity, the researcher used the modified math identity guidelines (Solomon, 2012) to analyze the DAM drawings and writing; these data were triangulated with quantitative findings (O'Donnell, 2008; Yin, 2013).

Markers of Math Identity

The researcher compared the number and quality of indicators (descriptions, actions, and aspirations) for all students (n = 36) both BOY and EOY. Next, the researcher used qualitative data to gain a better understanding of how the math identity development of one exemplar student, Cardi, fit into the thematic framework. EOY DAM mathematician descriptions used fewer descriptive words than those written in the BOY. Where students did use descriptors, there was a shift from stereotypical words like *nerd* or *geek*, to more universal language (*anyone* can be a mathematician). Another finding was that learners, despite their level of parent-student TIPS participation, increased the number of math applications and aspirations that they included in their writing samples. Half of the groups increased the number of math related actions described. The embedded qualitative data showed that the overall number of math identity indicators in student writing increased as parent-student participation rates rose. Without a comparison group, changes cannot be attributed to the intervention; however, a relationship also cannot be ruled out.

Table 15

The Influence of Home-Based Math Learning on Math

	BOY actions	EOY actions	BOY descriptions	EOY descriptions	BOY aspirations	EOY aspirations
83-100%	1.4	0.79	1.4	0.43	0.14	0.86
58-82%	1.1	1.6	1.2	0.78	0.67	1.1
33-57%	1.25	1.5	2.0	0.0	0.5	0.75
<32%	0.8	0.2	2.0	0.6	0.0	0.4

Leila

Leila's father, François talked about parents who "brush off homework—Not because they didn't want the kids to do it, but because they were embarrassed because they didn't understand it." His metacognition about some of the barriers that prevent parents from supporting their children's academic growth, empowered the way that François' supports his daughter's math learning at home (RRD, MAH, PSE). He emphasized several times in the focus group discussion that he is not content to not understand. François uses Google to find answers and asks for help as needed (FG). He and his wife endeavor to give Leila and her brother rich math opportunities at home. Leila's parents help her understand the value of conceptual knowledge by discussing the value of learning “what was behind it (the math problem),” not just procedures (OVN). These math opportunities influence Leila’s level of confidence with math.

She said, “I know how to do my yellow homework cause my parents motivated me. I was able to do it because of them” (CSE, TIPS; Leila, FG). The researcher observed that Leila had tremendous sense of herself as a math learner. She exuded confidence (anecdotal observation of the researcher). Ms. Vader’s impression of Leila both BOY and EOY was that Leila was confident about math, and also that she put strong effort into her math work (teacher observation). Leila had many ideas about how she might apply math to her future. She has decided to. be the first girl who makes a profit off of coding, because “I don’t know any girls who code, I code, I don’t know any girls who code, like and actually make a really good profit and living off of it” (MIF; Leila, FG). Her aspirations, like her sense of belonging to the math community of practice, were strong. In Leila’s case, home-based math experiences did seem to support her math identity and pave the way to a host of math aspirations.

Summary Response

Students’ lexical choices give clues to how students think about themselves as math learners. Children with a vague conceptual understanding of math are likely to describe actions with less specificity, to describe mathematicians with stereotypes, and to have limited vision about the mathematical opportunities that exist or about their own future with math. Despite the decrease of descriptive indicators in the DAM writing samples, the increase of math action and aspiration indicators supports the possibility that students’ math identity developed over the course of the year. The researcher posits that a student’s knowledge of ways to engage in math (actions), and their future aspirations are stronger indicators of math identity than a knowledge of descriptive words to describe a mathematician. When a student describes a mathematician; the quality of this conceptualization depends on the student’s level of awareness about what it means to belong to the math community. Knowing *how* a mathematician participates in a community of practice requires a more intimate experience within that community. Aspirations, a students' subjunctive understanding of what is possible in a math community and where they want someday to be within that possibility, also require conceptual knowledge of the math community of practice over time.

Summary of Research Question 3 Findings

The final research question explored how Black female students' descriptions of themselves as math learners correspond with their math achievement scores. To answer this question, the researcher compared math identity and math achievement data for all student participants (see Table 9). The measures used to make this comparison were (a) DAM test scores, (b) the teacher's BOY and EOY observational measures of students' math effort and students' confidence with doing math, and (c) student grades. Qualitative data were used to further explore how a relationship between math identity and math achievement situates these girls as members of a community of math learners.

Math Identity and Learner Enculturation

Theme 3 explored how a strong math identity may help deepen learners' enculturation into the community of mathematical knowledge, practice, and belief. Math identity was measured by the number of an individual's racial or gender identities that were included in their drawing of a mathematician (DAM). These data are especially relevant to this theme because they indicate the extent to which Black female mathematicians exist in students' imagination, and subsequently in their perception of the world and its possibilities. The girls in the focus group (n = 4) drew three White female, and one White male mathematician in the BOY. Postintervention, Leila drew a White female and the other three girls drew Black female mathematicians. Overall, the Black girls in Ms. Vader's class' math identity scores increased over the course of the intervention (see Table 9). In the focus group, students made more comments that reflected high self-efficacy with math than low (15.4% compared to 2.9%). Still, the whole class (n = 36) data are troubling; although girls drew male mathematicians, and Black students drew White mathematicians, no White students drew Black mathematicians, and no boys drew female mathematicians (DAM), a reflection of a cultural bias for White male mathematicians. Though they shared no racial barriers to math learning, the students agreed that gender barriers inhibited their math learning. Kitty said, "Too much drama, caught up in relationships … and stuff, and it's kind of a lot" (GF). Adult participants called for better math role models (CF, MIF). The primary aspiration expressed by the girls was to be a math teacher, and as Elmer mentioned, "Just think it's pretty evident that there are too few role models for these young women…. the only thing that they are thinking of right now is teaching, and there is so much more out there." Leila said she wanted to be the "first girl that I know to make a profit off of coding," which showed that although her aspirations and sense of herself as a math learner were robust, she might benefit from role models or other strategies to acquaint her with the history of and opportunities in the math community. The girls in the focus group's descriptions of themselves did correspond with their math achievement scores. The focus group data helped to describe how learners' math identities helped deepen their enculturation into a math community.

Enculturation of Focus Group Members

The codes that support theme three are CSE, MAH, GF, and MIF. Two subcodes that emerged from MAH are PK (procedural knowledge) and CK (conceptual knowledge). Here the researcher relied on a math identity guideline modified from Solomon's (2012) definition. Focus group content was analyzed for evidence of student engagement in math, student descriptions of math, and students' math related aspirations. For engagement in math, the researcher looked at the kinds of activities that students did and labeled them as procedural or conceptual. The researcher found nine examples of conceptual, and 11 of procedural knowledge building. Examples of procedural knowledge include: double check and triple check answers, skip counting, learn steps to solving multi-step problems, Examples of conceptual knowledge development include using context clues, figuring things out, connecting math learning to everyday experience, putting things together (models, experiments), using math language that supports conceptual development (talking them through frustration, or modeling problem solving).

The students used concept-oriented language throughout the focus group. Leila said that learning skills in her coding class “was setting me up for success,” indicating an awareness of how important learning new skills is in the math community of practice (PK, CSE, MAH). Kitty verbalized her strategy for solving a multi-step problem, including strategies for when she doesn’t know how to proceed, “I point out the words that I don’t know, and I point out the words that I do know and I try to use my context clues and try to use the words around to find a clue that will help me” (CK, CSE). For the most part, the girls in the focus group used language to demonstrate their math identity and sense of belonging. One exception was Cardi. Like the other girls, Cardi said that she felt more confident after doing TIPS, but beyond that thought, Cardi did not talk much about math. The most common aspiration that the girls had was to teach math. Other aspirations included working at Starbucks, getting a doctorate, and coding.

Summary Results

Guided by Solomon’s (2012) definition of math identity, the focus group girls are developing the language and actions that will enculturate them in math communities of practice. These students have aspirations, but with more access to role models, they may develop aspirations that indicate a more nuanced understanding of the role that math plays in the world.

Discussion

The intended theory of change for this intervention was predicated on an idea that contextualizing math learning in a family-school relationship would increase parent self-efficacy with supporting daughters as math learners (Epstein, 1987). This in turn would lead to increased family-school engagement (Epstein & Van Voorhis, 2001; Van Voorhis, 2011), as well as increased student sense of themselves as math learners. The desired long-term outcome was that the treatment would increase Black female participants' math identities, increasing the possibility that they might take and succeed at the higher-level math courses that prepare them to succeed at STEM careers (Archer et al., 2015; Berry, 2008; Eccles, 2005; Entwistle & Alexander, 1989; Epstein, 1988; R. Gutiérrez, 2000, O'Sullivan et al., 2014; Van Voorhis, 2011).

Dowling (1996) wrote that one does not learn only knowledge in a mathematics classroom; one also learns practices. It follows that children learn more than knowledge when they do math activities with their parents at home. The mathematical practices that parents impart, no less than those learned in school, support the enculturation through which students become participants in the community of mathematicians, able to "turn their tacit knowledge into explicit knowledge to be used to further develop the community of practice" (Gee, 2008, p. 93). This research intervention explored the relationship between parent-student participation in an interactive homework, TIPS, and several variables that contribute to student math identity.

First, the researcher examined a relationship between parent participation in TIPS and the development of parent self-efficacy to support their daughters as math learners. Discussed next was the question of whether student participation in a home-based, interactive math homework would influence students' math identity. The final research question investigated whether student math identity would converge with student math achievement. Each of these questions contribute to an exploration of how home-based math activity supports the development of Black girls' math identity as well as their enculturation into a math community of practice. The findings give the sense that the interactive homework, TIPS, had a positive influence on each of the variables. Participation in TIPS influenced parent self-efficacy with doing math activities at home in some cases. Participation in TIPS influenced students' sense of themselves as math learners.

Additionally, an impressionistic connection was made between student math identity, student math achievement, and student sense of belonging in math environments.

Limitations

This study had with several limitations. First, without a comparison group, there was no chance to determine whether the intervention had an effect on the participating families. Without a comparison group, it was especially difficult to confirm that the intervention itself influenced the research outcome. Confounding variables might include student maturation (the students' developmental growth might have contributed to the outcomes), teacher (the teacher's pedagogical strategies might have contributed to the outcomes), and so on. Having pre and postintervention focus groups would have added validity to the study outcomes.

Though most data were collected with fidelity, a low number of participants took the MSPSE (Bandura, 1989), which was needed to collect information about parent self-efficacy with supporting their daughters as math learners. Further, the scale did not include the identifying questions that would have made it possible to compare information by racial or gendered subgroup. Another weakness was that it was fairly easy for the researcher to distinguish between gender identities on the DAM test; however, it was not always possible to determine the mathematician drawn by the student's race, If students clarified with words that the mathematician belonged to a certain racial group, the researcher could give a point (or not) for the identity construct even without a clear drawing. Where indicators were not clear, the researcher did not give a point.

Another possible limitation was the relative homogeneity of the focus group which was comprised of three of the highest achievers in Ms. Vader's class, including Rainbow Unicorn and Leila, who were "like Ms. Vader technically," according to Leila, because they would help other students with their homework and problems. Though Cardi was in the middle tier of achievers, her grades had consistently increased over the year. Having a group that was more academically diverse with members in the high, low, and middle perhaps would have added richness to the focus group discussion. It also would have been wonderful to have had both a pre and postintervention group for both a comparison and treatment group as originally intended.

Future Considerations

Families said that they appreciated TIPS (Family TIPS Survey, Focus group feedback). All parents, and most children would like to use TIPS again next year (FTS). There is something simple, yet powerful about homework framed in Bronfenbrenner's (1977) idea that individuals' bidirectional interactions are shaped by several overlapping spheres of influence. Given parents' relatively low scores on the sections of the MSPSE that measure efficacy with influencing events that occur in school, the researcher wondered if the family-school partnership that is paramount to the success of TIPS could be expanded to position parents more directly as decision-makers within the school context.

TIPS has been a successful strategy for strengthening family-school partnerships for almost twenty years. It has been revised over that time, but the format has not significantly changed. The researcher suggests that making some changes to TIPS might make homework more relevant to a wider range of families. First, the homework could be updated to incorporate current and local events and activities, including those that require technology. Next, the homework could be recalibrated to better fit the curricular needs of a given class or academic community. Finally, TIPS could be rewritten to be more culturally responsive to school families, and more inclusive of diverse cultural perspectives.

The researcher envisions using a participatory action research framework with individual school communities to reevaluate and revise TIPS. Directions on how to develop and implement TIPS homework are available to educators (Epstein & Salinas, 1995), which could also be used to guide a collaborative family-school partnership. Researchers should collaborate with parents and teachers to create interactive homework that aligns with students' academic needs, while increasing students' opportunity to learn by providing a culturally relevant experience to a diverse group of students. Working with small groups of parents at individual schools would be labor intensive, and less efficient than conducting a top-down intervention with a larger number of schools. However, contextualizing academic math learning within the key socioecological interactions of home and school would both provide an insider's perspective for reevaluating TIPS and support the family-school partnership at participating schools.

Conclusion

For students at CPS, TIPS, an interactive homework, was a successful medium through which teachers, students, and parents interacted to support students' math learning. Not only did most students and parents enjoy TIPS, many credited TIPS with improving their home, and subsequently school math experience (Family TIPS Survey, focus group). Whether the intervention itself contributed to any desired outcomes is inconclusive as the gains experienced by students could be contributed to other factors. The data did show evidence of a relationship between parent participation, parent self-efficacy, work effort, math identity, student self-efficacy, and math achievement. First, when qualitative data were embedded in the quantitative data, the researcher noticed a connection between the parents' support for their daughters' math achievement and the development of parental self-efficacy. Second, an impressionistic relationship was found between students' participation in TIPS and the development of students' math identity. Third, a relationship was found between the math identity and math achievement.

Math identity is a key predictor of students' sense of belonging in math communities, as well as their immediate and long-term success in mathematics (Martin, 2012; Phan, 2013; Tschannen-Moran et al., 2013). Contextualizing math learning in the overlapping spheres of home and school experiences (Bronfenbrenner, 1998; Martin, 2012) did seem to influence how the Black girls in this research intervention saw themselves as math learners. A deeper and more extensive research into the relationship between home-based math interventions, math identity, and math literacy as they support students' belonging in math communities of practice would build on the impressionistic findings gathered here.

Table 16

Summary Matrix Table

Indicator	Instrumentation	Data collection	Data analysis
Increase in student math skills	Grades	Collected by teacher for all students	Descriptive
Increase in parent self-efficacy	MSPSE	Postintervention collected by researcher	Descriptive
	Focus group; Family TIPS Survey	Recorded postintervention; coded and analyzed by researcher	Deductive/inductive analysis
Student math identity	Draw-A-Mathematician (DAM)	Pre/post by teacher	Transcripts coded and analyzed thematically
Parent participation in TIPS and parent self-efficacy with supporting child as a math learner	Focus group parent signatures on TIPS; FTS items; Focus group responses	Postintervention by researcher TIPS and FTS collected by teacher and given to researcher Focus group conducted by researcher	Analyzed descriptively (QUAN and QUAL) and then triangulated
Student participation in TIPS and student math identity: Black girls' math identities and math achievements	Parent signatures on TIPS; DAM drawings; DAM drawings and written responses;	Collected by teacher	Analyzed descriptively and then triangulated
	Students' grades	Collected by teacher	Analyzed descriptively and then triangulated

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Appendix A

Focus Group Themes

Theme	Parent discussion point
Gender related	Teach positive image about math at home.
	Teach positive images about math at school.
	Introduce students to positive Black female role models.
	Encourage girls: “You can succeed in math, math is achievable.”
	Cultural and social negative messages about women in math
	Mother/family reinforce bias against women in math
	Boys are wired differently/better at math.
	Gender makes no difference with math learning
	Toys reinforce different orientation toward math.
	Boys more independent learners than girls.
	Schools have low expectations of female students.
Racial identity	City schools track kids into service careers
	Low expectations for Black students
	Counter-narrative needed to succeed can be stressful.
	Race is “a strike against you.”
Family-school	Parents try to interact with schools.
	Parents cannot connect with school math.
	Low self-efficacy with supporting child’s math achievement
	Parents do not know how to advocate for child.
	Parents do not have time to advocate for child.
	Parents visit schools.
	Parents find out what work students are doing in class.
	City schools push children through.
Pedagogical	Girls need to understand what they are learning.
	Real-life applications are valuable.
	“School math” is different than “my math.”
	Hands on work is positive.
	Social learning is helpful.
	Parents value peer teaching.
	Teach that there are multiple ways to solve problems.
	Like that Montessori teacher stays with class for three years.
	Girls need core skills to build on as they advance in math.

Appendix B

Needs Assessment Focus Group Questions

- What do you wish had been different about math when you were in school? What did you enjoy?
- How do you use the math that you learned in school today?
- In a perfect world. What does math class look like for your daughter?
- Now, let's talk about your daughter and math. How does your daughter feel about math? Does she see herself as a math learner?
- Think about careers. What would you like for your daughter to do when she grows up?
- Let me ask you, how do you see that (career aspiration) meshing with math...
- From your experience, how do you think boys and girls learn differently?
- Historically, in Baltimore and in our country, the playing field has not been equal for all races and genders. This inequity continues to affect many aspects of our lives from how we are treated in traffic to our access to health care. How do racism and sexism affect learning? How do they affect learning for your daughter?
- What could a teacher do to help you feel more connected to what is happening at school?
- What is one thing that would help your daughter to see herself as a math scholar?

Appendix C

Draw-A-Mathematician Table

Draw-A-Mathematician Results

Student	Identities shared	Comments
Asian girl	Two	My mathematician is a smart woman that is smarter than most men but all men under-estimate her. I'm independent just like her.
Black girl	Two	No comment
Black girl	Two	No comment
Black girl	Two	My mathematician studies science and loves doing experiments. She is 31 years old and lives in a small apartment in Brooklyn, New York on the 108th block. I am like the Mathematician because I am also a girl. We have the same hair and eye color and we both like science.
Black girl	Two	Brown hair…..light skin. She enjoys gaining Skills in math and loves having help. We are Both not perfect at math but we always try.
White girl	Two	She is a top class worker who has dedicated her life to math and teaching others advanced math.
Black girl	One	She was talented and smart in many ways and ideas to do things easily for her class to understand.
White girl	Two	I'm a mathematician. I drew the world because the world is made of math. Without it, this world wouldn't be at all functioning. I believe that everyone is a mathematician.
Asian female	Two	My mathematician is my mom. She has Black Hair. She's pale. She deals with sex offenders. She was really good at math in high school. I'm not good at math like her.
Black girl	Two	My mathematician is….me! She has dark brown curly hair, dark red glasses, brown eyes. I'm African-American and I play soccer. Skeptical about math. It's confusing. But once I practice it, I'm an expert. I consider math as something you need to practice over and over again.

Black girl	One	He wears a pointy hat that is dark blue with gold stars. He can be any race. I don't think that I'm anything like Marty (my mathematician). He is a fairytale in a magical way because math is magical. When I do a PEMDAS or a DMSBD problem, I feel magical.

Note. 26 students took this test. Eleven students turned in IRB forms.

Appendix D

Sample of TIPS Homework

Student's Name ___________________________ Date ________________

COMPARE NUMBERS USING <, >, OR =

Dear Parent/Guardian,

Let me show you what we learned in math. We can enjoy "Let's Find Out" together.

This assignment is due ________________.

____

Student's Signature

LOOK THIS OVER Explain this example to your family partner.

4,583 > 4,538

STEP 1

Read the number, and count the digits. Do they have the same number of digits? If yes, go to STEP 2. If no, which is greater?

STEP 2

Compare each digit, starting with the first digit on the **left**. Continue until the digits are different. Which is greater?

4 = 4, 5 = 5, 8 > 3

Since 8 > 3, 4,583 > 4,538.

NOW TRY THIS Show your family partner how you do these examples. Compare using <, >, or =.

976 ___ 3,212

4,875 ___ 4,877

If you need help, ask your family partner to go over the example with you.

PRACTICE SECTION Complete these examples on your own. Show your work. Explain one example to your family partner.

Compare using <, >, or =.

1. 346 ___ 986
2. 899 ___ 2,011
3. 453 ___ 534
4. 397 ___ 3,971
5. 4,571 ___ 4,715
6. 3,876 ___ 8,714
7. 1,001 ___ 989
8. 6,485 ___ 5,846

******CONTINUE YOUR WORK ON THE BACK OF THIS PAGE******

MORE PRACTICE Write the correct number.

1. The smallest number with the digits
   6,9,8,7,4,and 3 ___________

2. The largest <u>even</u> number with the digits
   1,1,1,1,4, and 9 ___________

3. The largest <u>even</u> number with the digits
   6,4,1,2,1, and 1 ___________

4. The smallest number greater than 500,000
   with the digits 6,7,1,5,0, and 4 ___________

5. The smallest <u>odd</u> number greater than 400,000 with
   the digits 5,4,7,4,1, and 1 ___________

LET'S FIND OUT Complete the following problem with your family partner.

Ask your family partner: "In what year were you born?"

Write the year. ________

Write the year <u>you</u> were born. ________

Compare the 2 years using < or > or =

____________ ____________

ANSWERS TO NOW TRY THIS

976 < 3,212

4,875 < 4,877

HOME TO SCHOOL COMMUNICATION

Dear Parent:
Please let me know your reactions to your child's work on this activity.
___1. O.K. My child seems to understand this skill.

___2. PLEASE CHECK. My child needed some help on this, but seems to understand.
___3. PLEASE HELP. My child still needs instruction on this skill.

___4. How did you support your child with this task?

___5. PLEASE NOTE (other comments). ____

____

Parent's Signature: ____

Appendix E

Treatment of Thought

Inputs	Intervention components.	Underlying processes	Intermediate outcomes.	Educational Outcomes
Approximately 40 fourth-grade. students	Get buy-in from school.	Increased family-school engagement. facilitated by TIPS. interactive home-work	Increased Parent self-efficacy with supporting daughters as math learners	Increased student sense of themselves as math learners.
Approximately 40 parents	Choose 12 TIPS homework. with teacher			
One math teacher	Discuss process and fidelity with teacher.		Increased student math achievement	
Letter to parents	Send letter to parents with a rationale and expectations			
IRB form for. each student.				
Time to meet with head of school and teacher	Teacher discusses expectations with students			
12 TIPS homeworks per student.	Do pre-tests with students in class, and have parents sign IRB and take MSPSE.			
40 copies of each measure DAM TIPS surveys (family and student) MSPSE	Send home TIPS every two-weeks. Collect TIPS every two-weeks.			
12 Protocol Sheets for teacher	Teacher checks off items on the protocol sheet each week and evaluates TIPS.			
BOY and EOY teacher. observation sheet	Teacher administers post-intervention			
Student grades	measures.			

Focus group. questions 3-5 parent-child dyads to Participate in Focus group. Meeting place for focus group: food and drink, recording device. gift certificates for each family. childcare if Needed.	Members of focus group selected by teacher. Researcher conducts focus group. Researcher analyzes data. Researcher presents findings to stakeholders.

Appendix F

Multidimensional Scale of Perceived Self-efficacy for Parents

PARENTAL SELF-EFFICACY SCALE (Bandura, 1989)

This questionnaire is designed to help us gain a better understanding of the kinds of things that make it difficult for parents to influence their children's school activities. Please indicate your opinion about each of the statements below by circling the appropriate number. Your answers will be kept strictly confidential and you will not be identified.

EFFICACY TO INFLUENCE SCHOOL-RELATED PERFORMANCE

How much can you do to make your children see school as valuable?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to help children to do their homework?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to help your children to work hard at their school work?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to get your children to stay out of trouble in school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to discourage your children from skipping school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to help your children get good grades in school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to teach your children to enjoy school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to show your children that working hard at school influences later successes?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

EFFICACY TO INFLUENCE LEISURE-TIME ACTIVITIES

How much can you do to get your children into activities outside of school (for example, music, art, dance, lessons, sports activities)?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to help your children keep physically fit?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you involve yourself with your children in their leisure activities?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

EFFICACY IN SETTING LIMITS, MONITORING ACTIVITIES AND INFLUENCING PEER AFFILIATIONS

How much can you do to keep track of what your children are doing when they are outside the home?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to prevent your children from getting in with the wrong crowd of friends?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to get your children to associate with friends who are good for them?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to get your children to do things you want at home?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to manage when your children go out and they have to be in?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to instill your values in your children?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to spend time with your children and their friends?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to work with other parents in the neighborhood at keeping it safe for your children?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to keep your children from going to dangerous areas and playgrounds?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

EFFICACY TO EXERCISE CONTROL OVER HIGH-RISK BEHAVIORS

How much can you do to prevent your children from doing things you do not want them to do outside the home?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to prevent your children from becoming involved in drugs or alcohol?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to prevent your children from becoming involved in premature sexual activity?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much could you do if you found your children were using drugs or alcohol?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

How much could you do to stop your children if you found that they were sexually active?

1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal

EFFICACY TO INFLUENCE THE SCHOOL SYSTEM

How much can you do to influence what teachers expect your children to be able to do in schoolwork?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to influence what is taught in your children's school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to make your children's school a better place for children to learn?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to influence the social activities in your children's school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get parents involved in the activities of your children's school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to influence the books that are used in your children's school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to make your children's school a friendly and caring place?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to make parents feel welcome in your children's school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to influence what is taught to your children?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to influence what your children do after school?
123456789 Nothing Very Little Some Influence Quite a Bit A Great Deal

EFFICACY TO ENLIST COMMUNITY RESOURCES FOR SCHOOL DEVELOPMENT

How much can you do to get neighborhood groups involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get churches involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get businesses involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get boy scouts/girl scouts involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get the YMCA/YWCA involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get a Private Industry Council involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

How much can you do to get advocacy groups such as the Urban League,. NAACP, or Anti-Defamation League involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get local colleges and universities involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get local health clinics and hospitals involved in working with schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to get public funds for specific programs in the schools?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

EFFICACY TO INFLUENCE SCHOOL RESOURCES

How much can you do to help your children's school get the educational materials and equipment it needs?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How much can you do to influence the size of the classes in your children's school?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

EFFICACY TO CONTROL DISTRESSING RUMINATION

How well can you stop yourself from worrying about things?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you take your mind off upsetting experiences?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you keep yourself from being upset by everyday problems?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you keep your mind on the things you are doing after you have had an upsetting experience?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

RESILIENCY OF SELF-EFFICACY

How well can you keep tough problems from getting you down?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you bounce back after you tried your best and failed?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you get yourself to keep trying when things are going really badly?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you keep up your spirits when you suffer hardships?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you get rid of self-doubts after you have had tough setbacks?
1 2 3 4 5 6 7 8 9

Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you keep from being easily rattled?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal
How well can you overcome discouragement when nothing you try seems to work?
1 2 3 4 5 6 7 8 9
Nothing Very Little Some Influence Quite a Bit A Great Deal

Appendix G

Logic Model

Theory of Change for an Intervention to Address Math Underperformance of Black Girls

Value creation	Inputs	Activities	Outputs	Outcomes		
				Short	Medium	Long
Priorities Family-school engagement Parent self-efficacy Student sense of self as a math learner Interactive homework (TIPS) Situation Math underperformance Black girls Diverse public school Embedded design	Time: Six-months for project; Planning time with teachers Measures; Draw-A-Mathematician, General Self-Efficacy test, Teachers Involve Parents in School (TIPS) survey, Students' grades, Parent TIPS survey Student TIPS survey Materials TIPS materials TIPS—directions and rationale for parents Room, food, child care, and gift cards for focus group	Choose TIPS tasks that align with math curriculum Introduce TIPS to participants (letter and/or meeting) Administer pre research measures Hold a focus-group with four parent-child dyads. Introduce TIPS to students using protocol sheet Collect, evaluate, and analyze biweekly homework. Post research Measures and analysis.	Strengthen family-school partnership. Future families who will participate in TIPS Teacher who will implement intervention. Parents of Black girls who will participate in a focus group with their daughters Head of school (key evaluation stakeholder)	Parent self-efficacy with supporting daughters as math learners will increase Students' math scores will increase	Students will develop a stronger sense of themselves as math learners Family-school engagement will increase	Students will be more likely to take and succeed at high level math classes.

Appendix H

Protocol Check-Off Sheet for Teachers

Teacher Check-Off Sheet

Date ________________

Check off each item on the sheet as you complete the action.

1. Teach skill needed to complete homework. _______

1. Introduce homework to students (five minutes)
   a. Review math skill. _____
   b. Remind students to work with their homework partner if possible _______
   c. Review homework requirements. _______
   d. Remind students of homework due date. _______

3. Count completed homework. _______

Number of completed homeworks	Total number of Students

4. Review homework. (five minutes)
   a. Check homework with group. _______
   b. Collect homework. _______

5. Respond to parent comments. ________

Appendix I

Teacher Observational Checklist

Checklist sample

Student 1.	*How much effort does the student put into work?*	The student works hard.	The student does most work.	The student does very little work.	The student does not work.
	How confident is the student about their ability to do math?	The student is very confident about their ability to do math?	The student is usually confident about their ability to do math?	The student is sometimes confident about their ability to do math?	The student is not confident about their ability to do math?
Student 2.	*How much effort does the student put into work?*	The student works hard.	The student does most work.	The student does very little work.	The student does not work.
	How confident is the student about their ability to do math?	The student is very confident about their ability to do math?	The student is usually confident about their ability to do math?	The student is sometimes confident about their ability to do math?	The student is not confident about their ability to do math?

Appendix J

Intervention Timeline

Date	Stage	Task
August – September	Preintervention	Prepare testing and homework materials. Prepare outreach materials.
September	Preintervention	Receive IRB permission Collaborate with teachers about implementation Inform parents and children about the intervention.
Early October	Preintervention	Collect preintervention data.
May	Postintervention	Postintervention data collection. Meet with postintervention focus group.
May - July	Postintervention	Analyze and interpret data. Share findings with stakeholders.
November - May	Postintervention	Distribute TIPS every 2 weeks for 6 months (allowing time for breaks and school events).
May	Postintervention	Collect postintervention data. Conduct postintervention focus group.
May	Postintervention	Analyze and interpret data. Share findings with stakeholders.

Appendix K

Focus Group Questions

1. What were/are some of your favorite things about learning math?
2. What, if anything, makes it difficult for girls to learn math?
3. How about race or ethnicity. Do you think that these pose barriers to math learning?
4. Specifically thinking about math, what kinds of math activities do you do together at home? This could include conversations, activities like cooking, or standard math worksheets.
5. How confident are you (homework partner) about preparing your child for the kind of math that is used on PARCC and tests like that?
6. What strategies do you use when your child does not understand a math problem?
7. How confident are you (child) about taking a test like the PARCC?
8. What do you do (child) when you see a math problem that is confusing or difficult?

Appendix L

Focus Group Themes and Codes

Themes	Codes	Description	Exemplar statement
Family-school partnerships focused on math can help support mathematical self-efficacy for parents and their children.			
	CSE	Children's self-efficacy with math learning,	I feel a lot more confident, because my parents are able to help me with it. I feel like I'm able to explain how it is (FG, Leila).
	PSE	Parental self-efficacy with supporting their children as math learners.	I just use humor, cause she already knows it, she just needs, I don't know, what's the word, she just needs encouragement (FG, Valencia).
	MAH	Math at home: math Related activities that Take place at home.	At home, I do a lot of cooking, and when it comes to measuring, I also need to use fractions and knowing that was our next curriculum, it really helped me, and then I could easily do it without having to think about it (FG, Kitty).
	HSC	Home to school communication, especially related to math learning.	If you come to school with it and need to talk to them about it, they will. If you come after school, they will. Because the teachers want them to know. The good thing. They teach too it (FG, François). I think it would help for the parents that

Themes	Codes	Description	Exemplar statement
			were interested if there were resources for us (FG, Elmer).
	OVN	Old vs. New Math: Compares Pedagogical math Strategies from past and present.	I struggle with knowing what the expectation from the school is versus how I remember —I age myself—doing it forty years ago. Thirty years ago. I mean, things were very different (FG, Elmer).
TIPS an interactive family-school homework provides a structure for parents to engage in a variety of activities that can support their child's math identity development and possible school and workforce STEM aspirations.	TIPS	Tips Feedback	Loved the communication it added about what was going on in school (FTS). It's pretty easy and I get to spend time with my dad and I like it a lot (FTS).
	MIF	Math in the Future: shows opportunities to apply math in the future	I just think it's pretty evident that there are too few role models for these young women…. the only thing that they are thinking of right now is teaching, and there is so much more out there (FG, Elmer). If it was shown to them more often that this is the kind of math you would use as a doctor, this is the kind of math you would use if you were a….(FG, Valencia)
	GF	Gender Focus: A focus on gender identity.	Math anxiety in women, girls, and I guess just being aware of the fact that one

Themes	Codes	Description	Exemplar statement
			should be anxious, I was already anxious, and knowing that it existed, I guess it's still with me. So, I might have the attitude that I can't help her as much as she needs, so (FG, MayBell).
	.RRD	Family Race Related Dynamic: Factors that explain How Black parents Support children As math learners	So a minority who did not graduate from high school cause it was good enough to know how to count money, and then they dropped out to get jobs, cause that was what was necessary, now those parents aren't able to teach their children those high level math applications. (FG, Valencia).
A strong math identity may help deepen learners' enculturation into the community of mathematical knowledge, practice, and belief.			
	CSE (See above for a definition of these codes.		To me, being a mathematician means that you work hard, and even when you get the problems wrong you fix it (DAM, Leila).
	MIF		I love seeing how kids grow and see things differently, and if things are not computer based um in the future, then I would love to be a teacher cause it's just so exciting cause math

Themes	Codes	Description	Exemplar statement
			helps me because how am I going to teach math if I don't know math then how am I going to teach math to a bunch of ten and twelve year olds (FG, Rainbow)
	MAH		She just wanted to get it done and get it out of the way which I think comes from the —-you said there aren't any role models for them, but, I think it's not understanding the life application of math (FG, Valencia).

Note. FG = Focus group; FTS = Family TIPS Survey; DAM = Draw-A-Mathematician Test.

Appendix M

Epstein's Six Types of Parent Involvement

- *Parenting*. Assist families with parenting skills, family support, understanding child and adolescent development, and setting home conditions to support learning at each age and grade level. Assist schools in understanding families' backgrounds, cultures, and goals for children.
- *Communicating*. Communicate with families about school programs and student progress. Create two-way communication channels between school and home.
- *Volunteering*. Improve recruitment, training, activities, and schedules to involve families as volunteers and as audiences at the school or in other locations. Enable educators to work with volunteers who support students and the school.
- *Learning at Home*. Involve families with their children in academic learning at home, including homework, goal setting, and other curriculum-related activities. Encourage teachers to design homework that enables students to share and discuss interesting tasks.
- *Decision-Making*. Include families as participants in school decisions, governance, and advocacy activities through school councils or improvement teams, committees, and parent organizations.
- *Collaborating with the Community*. Coordinate resources and services for families, students, and the school with community groups, including businesses, agencies, cultural and civic organizations, and colleges or universities. Enable all to contribute service to the community.

Taken from *School, Family, and Community Partnerships: Your Handbook for Action* (2nd edition), Joyce L. Epstein, M.G. Sanders, B.S. Simon, K.C. Salinas, N.R. Jansorn, and F.L. Voorhis, Corwin, Thousand Oaks, CA, 2002.

Appendix N

Draw-A-Mathematician Table

Student	BOY 10/31/2018	EOY 06/05/2019
Rainbow Unicorn	Loves math, Maybe teaches math. Does math every chance. Adores math. Shows work well with math. Correct answers in math. Very smart. Obsessed with math. Example: Albert Einstein.	On the front is a. woman who is about to hop in her car across the street. In her hand she has her Master's degree. She is with her student to teach him some more math.
Cardi	Very intelligent. Very weird. Very smart and fun. Very focused. Very helpful and kind.	My picture is a teacher because teachers know math better than anybody else. How I know this is because they teach students new things every day so the students can be smart too.
Kitty	I think a mathematician is like someone who is really smart and studies math a lot and probably thinks math is an easy way to calm down if you were stressed at any point...Additionally, they might wear eyeglasses.	The person I drew was a lady who I thought would be a good mathematician, she is wearing a pink dress with blue pants and red shoes, she plays games on her computer.
Leila	I think a mathematician is a person who is smart. Adjectives: nerdy, helpful, smart, communicative, loves math.	I drew a picture of a child sitting at a desk solving a problem. I think that a mathematician is someone who does math. It doesn't matter who the person is or who they want to be. It doesn't matter how they solve the problem. What matters is that they try. You don't have to be a nerd, geek, or even smart to be a mathematician. To me, being a mathematician means you work hard, and even when you get the answer wrong, you fix it and try again.

Student	BOY 10/31/2018	EOY 06/05/2019
Black boy 1	I think a mathematician is someone that studies math and maybe somebody that teaches math and figures out how to do math different ways.	He is a person that is a dork that is smart.
Black boy 2	My mathematician can do more math than anyone. Additionally, he helps his friends with math sometimes. He is also from the X-squad, so that's why he's so smart: "Nerd kid, but I was smart"!	He does a lot of math like xx1000. He does it in his sleep! He even plays video games because his homework is done in a milla-second. "The math Dude" (he is boss at math).
White girl 1	My mathematician is obsessed with math and is very professional and when they do math, it's hard for her to stop because she loves it so much. This person is a woman named Alison Steinberg.	I drew a person who is doing math problems and trying their best. A mathematician can be anybody who tries hard at math and doing their best. This girl is one of the popular kids. Women and men and boys and girls can all be good at math.
White girl 2	My mathematician is a person who figures out math problems. If you didn't have mathematicians then we wouldn't know what 2X2 equals.	My mathematician is a professor at a very good college. He is giving a lecture about how numbers should be used and what we should use them for. A professor is important because if he wasn't teaching the Earth would be confused about numbers. Additionally, if students are looking for a good job (good jobs usually include hard math), that professor is teaching them how math works,
White boy 1	Mathematicians have to be very good at math. Some are even better at math than	I drew a mathematician with glasses and a science/math shirt. He is explaining his

Student	BOY 10/31/2018	EOY 06/05/2019
	computers. Mathematicians can solve things like the trajectory of a rocket,	thought process to other workers at NASA. The picture on the screen is the trajectory he thinks Apollo II should launch at. It's also a party for Apollo II about to launch.
White boy 2	My mathematician loves math. I am a boy with crazy hair. I like long term division, It's not that hard, my brother taught me.	Computers do all the work now. Humans are lazy.

Appendix O

Curriculum Vitae

Shannon C. Jeter
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Baltimore, MD 21202
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804/ 832-3859

Work History:

Baltimore Montessori Public Charter School

Lead teacher, upper elementary (fourth- through sixth-grade) June 2014- present

- Planned, and implemented the level-wide curriculum for history, science, geography, and social justice.
- Initiated and supported a level wide annual camping program where students from multiple classrooms planned and raised money for an annual camping trip.
- Focused on building family school partnerships by introducing parent-teacher talk time and home-school interactive homework.
- Building representative with Baltimore Teacher's Union able to successfully negotiate on behalf of teachers for contractual rights including duty free lunch and meeting times.
- Member of the equity committee and the leadership team.

Johns Hopkins School of Education

Teaching assistant, doctoral level June 2016 - present

- Multiple Perspectives of Learning and Teaching (two semesters)
- Research Methods I
- Mind, Brain, Science, and Learning
- Disciplinary Approach to Education (three semesters)
- Multicultural Education (two semesters)

Williamsburg Montessori School

Lead Teacher, lower elementary (first-through third-grade) June 2011-June 2014

- Designed and implemented curriculum in accordance with Montessori philosophy.
- Designed and delivered a project based Spanish language curriculum for all lower elementary students.
- Initiated a lower elementary camping trip, now an annual event (2011-2014).
- As a strategic committee member (2013-2014), I collaborated to gather information, run focus groups, and make decisions for school level strategic planning.
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Gloucester Montessori School

Lead Teacher, lower and upper elementary August 2001-June 2011

- Designed and implemented curriculum in accordance with Montessori philosophy for a mixed age (6-12 years) class.
- Accommodated student need to develop practical life competence and independence through involving students in age-appropriate life skills including participation in a food co-op, needlework, carpentry projects, and cooking.
- Collaborated with Virginia Institute of Marine Science to involve students in an oyster growing/ reef restoration project (2001-2009),
- Prepared upper-elementary students to participate in the Montessori Model UN (2010-2011).
- Facilitated student-planned, annual camping trips.

Rappahanock Community College

Adjunct ESL Teacher August 2010-June 2011

- Worked with a mixed level class (beginner-intermediate).

Ware Academy

Teacher August 1999—June 2001

- Developed and taught Spanish Curriculum (K-8).
- Taught Math (4th-8th), and Spanish (K-8) in a traditional academic context

Education:

EdD, **Johns Hopkins University**, Baltimore, MD 2019

MA TESOL, **The New School**, New York, NY 2013

Montessori Elementary II Certification, **IAMS**, Silver Springs, MD 2006

Montessori Elementary I Certification, **MECR,** Boulder, CO 2002

BA English, **William and Mary**, Williamsburg, VA 1989

Other Activities:

Cook at Baltimore Yearly Meeting Camp Summer (2005-2019)

Krav Maga February 2019-present